GAS JOURNAL

LIGHT ⁘ HEAT ⁘ POWER ⁘ BYE-PRODUCTS

[Founded in 1849 as the "Journal of Gas Lighting."]

PROPRIETORS: WALTER KING, LIMITED. OFFICE: 11, BOLT COURT, FLEET ST., LONDON, E.C. 4.

Telephone: Central 6055. —— Telegrams: "GASKING, FLEET, LONDON."

VOL. CLXXV., No. 3306.] WEDNESDAY, SEPTEMBER 29, 1926. [78TH YEAR.

EDITORIAL NOTES.

Impressions at the Institution Meeting.

THE annual meeting of the Institution of Gas Engineers—postponed from June—has made its contribution to the technical records of the industry. Upon it, the President (Mr. Charles F. Botley, M.Inst.C.E.) and all concerned can look with pride; especially the President, whose dignified and active conduct of the affairs of the Institution during the year—in the presence of a great domestic affliction, the distractions of a coal stoppage of long duration, and the heavy obligations it has imposed upon him, as upon every engineer and manager in the industry—has won for him great regard and respect. His Address which was published in June was a clear exposition of the current affairs of, and movements in, the industry; and the notes which he appended to it last Tuesday week emphasize its features. In the address, and in the proceedings at the meeting, we have a good portrayal of, for our industry, a distinct translation from what has been to what will be, as far as human vision and reason are able to present the future to our minds. In the work of the year, called for by impending changes, the President has had to take a large share as head of the industry's central Technical Institution, and he has given devoted service.

In the reports, papers, and discussions this year, a high standard has been set. This is as things should be; it is merely a compliance with the demands of the times. What is true of the subject-matter, is equally true of the changing personnel. The two are inter-related. To say this, is no reflection upon the men of bygone days. The men of the past were as keen as the men of to-day for the welfare and advancement of the industry. They worked within the compass of contemporary knowledge. They realized, as we do, that it is only by the progress of individual and collective knowledge that forward movement, with increased impetus, can be made in the essential and material things of life. An industry which does not move along *pari passu* with the rest of the world, must be left behind, and, fortunately for the industry, it has undeveloped resources which, with increased energy and knowledge, it is working to unfold and bring to its aid. The industry has set to work to elevate the training of its men; and this, and what has already been accomplished in the same direction by our technological institutions—the Leeds University particularly—is making a gradual impress upon men and gas technics. The outcome is disclosed in the contributions to the proceedings of the Institution and other of our technical organizations, to the ultimate benefit of the whole industry. A new interest is apparent—an interest born of greater knowledge; and added knowledge is an inspiring force which increases the energy of the individual possessing it to beneficial ends. These facts were so pronounced at the meeting that they could not be overlooked; and they must give satisfaction to all with the best interests of the industry at heart.

In the meeting and at the luncheon given by the President and the Council, another impression made was in regard to the activities of the Institution in co-operative work with other technical bodies. This is a growth which is being encouraged, and opportunity for increasing it is sought. The Council have made it part of their business not to let any occasion slip by where technical collaboration is necessary to uphold or advance the interests of the industry. What has been done in the past is well known. Closer alliances are now being effected with the fuel technologists and with the activities of our chemical friends. Coke, tar, and other substances are gas-works products which the chemist and the physicist find fertile ground upon which to exercise exploration with a view to new revelation and material gain. There is no line of demarcation which definitely separates the interests of fuel-using and chemical industries from those of the gas industry. There is inter-relation of interests which should be of mutual advantage. Even the electrical and the gas industries—competitors for business—have much in common as public utility concerns; the "much" embracing elements of political, technical, and commercial importance. It is significant to those who have deep introspection into these matters how much may be overlooked through a myopic condition created by trading rivalry. There are industries which by working together could produce joint benefit; but there are generally found in such industries limits which do their best to put a ban upon, or a barrier to, co-operation. Sir Charles Morgan, Mr. C. P. Sparks, and others at the luncheon spoke of the relations of the gas and electrical industries, and of the indications of movement to bring about better understandings. Mr. Sparks says the first thing that is required is to recognize that both industries are in the position of public servants; the next, to get to know one another better. To that end, the Joint Committee of the Gas and Electrical Industries should make good contribution. The two acting together should make a stronger force than by standing alone when they come up against, for example, political action affecting their interests, or influences which are growing in strength through organization or the insidious teaching of pernicious doctrines. And in other directions, there may be ways and means of doing something of reciprocal value. These are matters worth investigating, and not pushing aside because the mere thought of such a proceeding is irritating to a few peevish partisans.

Another thing which was learned through bringing to the Institution board professional and other friends from outside is that the doings of the industry during the long coal stoppage have been under observation, and have been admired. Upon the gas industry has fallen the great responsibility of being chief fuel suppliers during the past five months; and there were many complimentary references to the national service that has again been performed by it in a grave emergency. There have been many anxieties and difficulties; but day by day they have been overcome, save where the trouble has been due to the conflict of labour policy and local government duty—the latter being allowed to go by the board to the injury of the community, while the upholding of extreme labour policy has done no good to anyone—not even to the miners' cause. In conversations, we have heard of greater demands for gas, which have brought percentage increases; in others, there have been decreases of output. But, on balance, taking the country through, the strike period has probably seen practically an equality in aggregate output with the corresponding period of last year. Further, we do not suppose that more than 20 to 25 p.ct. of the total supply under

the Gas Regulation Act has suffered any reduction of calorific value, which means that the majority of undertakings—at any rate, the big ones—have kept to their pre-strike line of value. Naturally, the period has witnessed the use of many million gallons more oil for enrichment than might have otherwise been the case if there had not been the necessity for making the fullest use of C.W.G. plants. Experiences relating to the use of coal from abroad have differed. Generally speaking, the coal from America has yielded the expected therms; but there have been extra scurfing and other minor troubles. The coal from the Continent has not been consistently of good gas and coke making value. But these are times when the coal that is available has to be obtained and utilized to the best advantage. However, this by the way. The satisfactory point is that the services of the industry to the country during the past five months are recognized, as indicated several times last week—by, among others, Mr. P. W. L. Ashley, C.B. (Principal Assistant Secretary of the Industries and Manufactures Department of the Board of Trade), at the luncheon, and the late Director of Gas Administration (Mr. H. C. Honey) early in the proceedings at the meeting.

The Physical Conditions of the Charge.

A point that has often been made in the "Journal" is that, in carbonizing practice, an extensive study has been made of the design of plant, fuel economy, temperature control, and the refractory materials used in the construction of the settings; but, until comparatively recently, very little attention has been given to the physical conditions of the charge, and their bearing upon productivity—quantitative and qualitative—in respect not only of gas, but of coke and the liquid products. This is surprising, having in view the vital importance of the charge in the matter of productive efficiency; also the cost of coal, compared with pre-war, demands that no justifiable means should be neglected that will make it more profitable.

From this year's proceedings at the meeting of the Institution, we find this element in the carbonizing operations—the charge—is receiving a great deal more scientific investigation than hitherto. The paper by Mr. T. F. E. Rhead, Chief Chemist of the Birmingham Corporation Gas Department, and the Sixteenth Report of the Gas Investigation Committee, will be highly valuable in opening-up a wider study of the influence upon productivity of the physical characteristics of the retort charge, through compelling a realization by gas engineers of the material importance of those characteristics. In the first place, we heartily congratulate the Gas Investigation Committee and Prof. Cobb on the thorough way Dr. Parker (the Research Chemist for this part of the work) and his assistants, Mr. Kerr and Dr. Monkhouse, have initiated the research into the influences of various factors on the yields, and physical and chemical properties, of the products obtained when different types of coal are carbonized. So far they have only dealt with the effects of size upon the yields of one Nottinghamshire coal. The retort used in their tests is a "Cronite" horizontal one, only 8 in. internal diameter and 4 ft. 9 in. in length, enclosed in a circular fireclay retort, with an annular space between the two. Mr. Rhead's investigation has been with a vertical retort in the working-scale experimental plant at Birmingham; and he has made such a complete research on two coals—one of them slightly swelling, and the other highly swelling—that the result is an important contribution to knowledge of the factors which affect the productivity of such coals in continuous verticals, with steaming. The matter which particularly interests us in both the Sixteenth Report and Mr. Rhead's paper is that of the influence of the size of coal upon what goes on within the retort, and upon the yields of products. But it will be seen that it is impossible to make any strict comparison between the results of the work given in the report and in the paper; for reasons due to dissimilar conditions. In the one case, we have an experimental horizontal retort; in the other, a continuous vertical retort and steaming. In one we have a static charge; in the other, a moving one. In the one, there is no steaming; in the other there is. Size of the particles of the charge in such circumstances can have no definite relation between the one system and the other. The work that the transmitted heat has to do is in the one case, owing to the steaming, much more complex than in the other; and thus it is obvious that the character of the charge must play an important part in respect of efficiency, both from the quantitative and qualitative points of view. Even superficial considerations will show that. But the point requires emphasizing, in order that the two contributions shall be studied separately to realize that method of operation has a bearing upon results with different sizes of coal. It will also be noted that there is a large difference between the temperature so far used in Dr. Parker's experimental horizontal retort and that employed by Mr. Rhead in the vertical retort. While, too, there is complete agreement with Dr. Parker that the work that is being done with the experimental retort is directed to securing fundamentals under perfectly concordant conditions, it is difficult to say that the results would be indicative of what would occur in a full-sized horizontal retort, where the mass of a charge with the fine coal as used in test "E" would offer a greater resistance to the penetration of the heat supplied than is the case with a charge in a retort of only 8 in. internal diameter. The heat resistance of the finer coal is indicated by the remark in the report that, in the early stages of carbonization, the rates of gas production were greater with the larger sizes of coal than with the smaller sizes, although in the final result the thermal production was greater from the latter; but this is attributed by Dr. Parker to the secondary decomposition of the tar—the tar make falling from 8·3 gallons with the largest size coal to 6·2 gallons with the fine coal. Mr. Rhead's larger gas make with 3 in. by 1¼ in. grade of coal was accompanied also by a larger tar yield—17 gallons against 13 gallons with the charge 90 p.ct. of which was below 2 in. and contained a considerable proportion of fines.

Certain of the findings in both report and paper—such as in respect of coke and tar—are confirmatory; but, from the gas-making point of view, there is divergence, inasmuch as while the fine coal in the horizontal retort gave the highest number of therms in carbonization, a more open charge in the continuous verticals supplied the best gas results, which shows that for the attainment of maximum therm results, the system of manufacture and size of coal must be considered together. Take Dr. Parker's tests "A," "B," "D," and "E," representing coals of these grades: "A," 1¼ in. to ¾ in.; "B," ¾ in. to ½ in.; "D," ¼ in. to 10 mesh; "E," 10 to 30 mesh. The therms made per ton in the experimental horizontal retort were: "A" grade, 72·3; "B," 73·9; "D," 74·1; "E," 75·8. There we see a gradual increase in therms as descent is made to the finest grade in size. This increase was confirmed in other tests. But turning to Mr. Rhead's vertical retort results with coal "A," which is a slightly swelling coal, and which gives 70 therms in horizontal working, we see that with 3 in. by 1¼ in. coal 82 therms were obtained; but the same coal crushed, with 90 p.ct. below 2 in., and containing a considerable proportion of fines, the therms were 76·7—the steam percentage in the former case being 10·48, and in the latter 10·16. Thus with continuous verticals and steaming, a better therm result was achieved with the larger coal, while the charge containing a large proportion of fines was less favourable in therms. The reasons for this (as suggested earlier in this article) point to the fact that with steaming the more open charge produced by the nut or cobble coal is an advantage, from the gas therm aspect—an advantage which would be denied with the finest coal used in Dr. Parker's test in the experimental horizontal retort, and which gave him the best thermal result in gas. The study which is being made by the Gas Investigation Committee of the effect of gas coal size, we take it, will when completed in the horizontal retort be carried on to verticals with steaming.

It would not be possible in all cases of vertical retort working to screen the fines from the general run of coal, and use them in horizontal retorts. But it is not beyond the ingenuity of engineers to prevent the segregation of coal in the hoppers which leads to discordant charges, in respect of size, in the retorts, and therefore to variable therm results per retort, although all other conditions are the same. With the cobble coal in Mr. Rhead's investigation, the rate of carbonization is increased by 20 to 25 p.ct., which is a matter of importance. Another lesson is that with the finest grade of coal in the Investigation Com-

mittee's researches, a coke was obtained more uniform in structure than the coke from the larger grades, and the walls of the larger cells contained a great number of very small pores. Mr. Rhead also found, in his vertical retort research, that, from the coal containing 90 p.ct. below 2 in. and a considerable amount of fines, a denser coke was obtained than from the cobble coal, which, on the other hand, gave a lighter and smaller coke—excellent for domestic fires. The same author advocates the steam quenching of coke, which, although it causes dust to blow about (means could surely be devised to obviate this), improves its brightness and appearance.

Both the report and the paper are highly valuable. As the investigation proceeds into the influence of size of coal and other factors—physical and chemical—in carbonization processes, the value will be greatly enhanced. We regard this as one of the best pieces of work the Gas Investigation Committee have taken in hand; and the painstaking and informative work of Mr. Rhead emphasizes this.

Economical Works Development.

UNTIL one comes to make a complete summary of a fully equipped modern gas-works, the aggregate of the advances that have been effected in practices and methods to realize economies and higher standards of efficiency is not completely grasped by the mind. Safe it is to say that, had it not been for the cumulative economies which have been made possible by the co-operation of invention and growth of business, the gas industry would not, in the circumstances of higher costs for material and labour, have been able, before the coal strike, to carry on at the then prices of gas, or to have made the headway it has done in the expansion of business. This being so, it is always a matter of interest to gas engineers to hear or read accounts by colleagues of the modernization and extension of plants—especially when the scheme of change has been directed to incorporating, with enlargement of producing capacity, economy and efficiency in all parts of the works. Of course, no engineer would criticize a fellow-engineer's adoption of any particular type of plant without first ascertaining the reasons for its selection, seeing that the causes, which may be purely local, may be fundamental to choice. In the paper by Mr. C. H. Rutter, the Chief Engineer of the Brighton and Hove Gas Company, we have a good engineering contribution, which shows how the author has elevated the standards of economy, efficiency, and production throughout the Portslade Works by, in their circumstances, the lowest possible expenditure of capital, consistent with the objects in view. More than once we have inspected the works, and have found interest in every part. The original works at Portslade were built by Mr. John Birch Paddon, who was a giant among gas engineers in his day, and was revered by them all. The original Portslade Works were built by him some fifty-five years ago. They then occupied only 7 acres (on the sea-board); now the area is approximately 40 acres. But Mr. Paddon was one of those engineers who built with what his contemporary Mr. H. E. Jones used to describe as "Roman fortitude;" and there are retort-houses in existence at Portslade which it would be wicked to destroy, though perhaps space-absorbing, compared with the area which some modern forms of carbonizing plant would require. It is probable that those excellently built houses have a considerable binding power in respect of the continued use of horizontal retorts by Mr. Rutter; it is also probable that he has a preference for them for the sea-borne coal which he uses. But the fact remains that Brighton and its environments have no cause to complain of the service rendered to them by the Gas Company from the Portslade plant.

Since 1919, continuous development has been proceeding on the works, and that seven years has meant a busy time for Mr. Rutter; but the result is that to-day we have presented there a well-co-ordinated plant from coal reception to the issue of the products from the works. If Mr. John Birch Paddon was here to-day, he would recall the 9000 to 10,000 c.ft. of gas that he used to produce per ton of coal on the site where advances in carbonizing structures and method have made the same area productively much more fertile, and have lessened all carbonizing costs. The coal-carbonizing plant is now equal to a production of 8 million c.ft. per day, and the carburetted water-gas plant to 7 million c.ft. The features of the plant, and those of construction, are clearly outlined in the paper; and to refer to them in detail would be merely to repeat what the author has said. But there are a few points which may be emphasized. Mr. Rutter leaves no doubt as to his being a high-temperature man; for he works the retorts he has put in No. 2 retort-house at temperatures of 1350° to 1450° C.; and in this connection he pays a tribute to moulded fireclay retorts (74·4 p.ct. silica) of the same composition as those which have stood such remarkably high temperatures at Keighley. His retorts have already been working close upon 1000 days at those temperatures, and show no signs of wear. In that house, Mr. Rutter has introduced both moulded fireclay and segmental silica retorts; but, other than an experimental setting (which has been at work for a considerable time), he has not had the latter retorts under observation sufficiently long to afford any useful information. There is a thoroughness in the description, which will be useful in bringing matters of detail before other engineers who are constructing similar carbonizing plant. Take two points as examples. One is that, in building the settings, an allowance for expansion in the cross walls, where silica is used in the centre only, is made by inserting a sufficient number of "SX" board strips in the horizontal joints, and leaving loose joints vertically. When raising the heats, the strips are burnt out, and the expansion is accommodated without the slightest disturbance of the settings. The other selected example is that Mr. Rutter explains, in dealing with the combustion chambers, that the secondary air nozzles are so placed that anything falling from above cannot obstruct the free flow of air. The nostrils are formed of four special shapes for convenience in manufacture—a point sometimes overlooked; much inconvenience being caused both to brickmaker and to customer, as awkward shapes in 95 p.ct. silica often become distorted in the kiln. There must be congratulation to Mr. Rutter upon his excellent fuel result. Last year it was 7·4 lbs. per 100 lbs. of coal carbonized, or 1·48 cwt., or 11 p.ct. on the make of 13·5 cwt. of coke per ton of coal carbonized; and the sale of coke is 11·51 cwt. per ton of coal carbonized. This beats the London and Suburban Gas Companies, as shown by the data in Mr. F. J. Bradfield's tables in our issue for March 3 last. In connection with regeneration, there is warning against assuming that a black main flue means that the regenerators are doing their work most efficiently. This is often a mistake. The ingress of cold air through ill-fitting sight-plugs and dampers is an insidious enemy, as an examination of the CO_2 content of the gases in the main flue will show. Mr. Rutter submits that a simple calculation will reveal, however efficient a regenerator may be, that there is ample heat available for both regeneration and waste-heat boilers.

The coal-handling plant is of an extensive and complete order, dealing with the coal from steamer to the overhead coal bunkers and into store—the coal required for both retort-houses being from 700 to 800 tons a day. Rubber and canvas belt conveyors are the fashion to-day, and are justified by experience. The Portslade one, judging by the hundreds of thousands of tons of coal already transported by it, is good for a life, in terms of work done, of 1 million tons. Given attention to proper adjustment, and the ordinary lubrication of rollers and idlers, experience strongly recommends them; and for smooth running and noiselessness, they would be difficult to beat. In this connection, it is not by any means a bad idea to do as Mr. Rutter has done, in connection with the electric motors on this plant—limit their makes and sizes to as few as possible, even at the expense of a little excess of power, inasmuch as there is a compensating economy and convenience in the stocking of spare parts. A tabulated statement in the paper shows the makes, nominal B.H.P., and the actual H.P. used. A cheap supply of electricity is obtained on the works by utilizing coke breeze and recovered pan breeze. Regarding coke removal, we can bear testimony to the efficient working of the Drake transporter at Portslade, and to the value of the inclined coke-bench in reducing the moisture in the quenched coke, as well as to the comprehensiveness of the telpher sys-

tem. Further economy is being introduced into the large carburetted water-gas plant. This year waste-heat boilers are being installed; and it is proposed gradually to make the plant self-supporting in respect of its steam requirements.

There is a point to which the consideration of the makers of exhausting machinery is invited. In describing the modernization of this part of the plant, Mr. Rutter expresses the opinion that insufficient attention is paid to the size of the flywheels and the stroke of the engines driving the exhausters. The stroke is short, the flywheels are small, and usually two are provided. The idea no doubt is to contribute to the steadying of a quick-moving machine; but Mr. Rutter contends that one large flywheel between the engine and the exhauster is preferable when heavy work has to be peformed—the momentum of the large flywheel having a great effect in carrying the engine over the dead centre. The manufacturers of exhausters will perhaps have something to say on this point of preference. Probably their defence of modern practice will be of a larger order than the one as to the contribution of the two small flywheels to the steadying of the machine.

Mr. Rutter's paper has value not only as a description of the economical modernization and enlargement (along lines producing higher efficiency) of an important works, but for the several suggestions it contains from personal observation and experience. Not many engineers, in such contributions as this, submit a schedule of costs such as the author gives as an appendix to his paper; and this will be a part which will not be the least studied, having regard to the times through which we have been passing since the war in respect of costs of material and labour. Mr. Rutter can be heartily congratulated.

Service to the Consumer.

Maintenance.

SERVICE to the consumer is one of the several important subjects before the gas industry at the present time. The brothers McLusky—"John W.," of Glasgow, and "W. B.," of Halifax—were the joint authors of a paper dealing with the topic from two points of view. They have become protagonists or specialists in various aspects of gas service. In one part of the contribution, "John W." dealt with the maintenance of all consumers' appliances; in the other, "W. B." treated of his systems for making charges more equitable and consumption-stimulating. There are no half-measures about the McLusky methods in both respects; and their joint paper supplies the proof of their success. It was very opportune to bring both questions before the central organization of the chief executive officers of the gas industry, inasmuch as these are times in which the industry is shaping its plans and marshalling its resources for future development and permanent protection of interests.

Glasgow has now installed general and systematic maintenance without a direct charge as a policy in which a large faith has been engendered—first, owing to the deplorable condition in which gas fittings and appliances had been allowed to sink by their users, and, secondly, to the large satisfaction that has resulted, and which has brought in its train increased demand not only for gas, but for additional appliances. To-day the Glasgow Gas Department so value maintenance without direct charge that they would not relinquish it; and they appreciate now, as they never did before, how maintenance eases and develops business, and gives a large confidence, despite acute competition, in the future. Such confidence is an important thing in any public utility service. What Mr. John McLusky recommends to his fellow engineers and managers is the same complete maintenance system as has been planned, built-up, and is now in operation in the city he serves, and serves well. The scheme, the system involved, the card records and checks, and the work done, are all set forth in the paper. Naturally, in the inception of the scheme, time spent and outlay were greater on any basis of cost calculation, owing to the crudeness and defects which had to be eliminated, in order to bring appliances up to a proper standard. The system has to grow to normal state; and this means time and expense. But from one visit a year to all consumers in this big, densely populated city, it is hoped to have half-yearly visits. Including burners, cooking, heating, and commercial appliances, capped services (potential consumers), governors, and meter connections, the scope of the scheme comprises 1,830,198 points for inspection; or (excluding 291,324 meter connections), there are 5·28 units per meter under maintenance. The average cost per appliance—including labour, material, and oncost—is 7·39d.; and the average cost per therm made is 0·236d.; but in one year there has been an increase of over 45 p.ct. in the orders for new appliances. In the twelve months to May, 1925, the orders for cooking stoves numbered 4125, and gas fires 1233—together 5358. In the twelve months to May this year, the orders for cooking stoves numbered 5278, and for gas-fires 2497—together 7775, or 2417 more than in the preceding year. These figures are highly satisfactory; and yet they apply to a period embraced in the development stage. In addition to new business, work has fallen-off in the complaint section; and the prevention of dissatisfaction (which is better than having to cure it), and the reduction of complaints, have a value, through the saving of worry and expense, which, if not assessable in terms of money, we know is there.

It would have been almost strange if a scheme having the purpose of improving the lighting, cooking, heating, and power conditions of the people of Glasgow, had not produced hostility from some quarter. It did—from the Master Plumbers' Association, who seemed to think that it was an invasion of their "rightful territory." But judging from our recollection of the way the master plumbers had neglected this so-called "rightful territory" prior to the Gas Department taking it in hand, they had manifestly not regarded it as being of much account. What the Department have done has been to plant efficiency where inefficiency had become a luxuriant growth; and for the Department to cease their activities in this direction would be a hardship on the consumers, and a distinct violation of high standard policy in public service. To that the Corporation can never consent. As a matter of fact, the master plumbers have not the same resources as the Department for rendering such service without direct payment. However, the master plumbers are short-sighted. As Mr. McLusky points out, they must benefit, seeing that the satisfaction with the gas service engendered by the scheme must create more work.

Halifax Scales of Charging.

SUCH work—work which produces efficiency and therefore economy in the utilization of the agent—presents a distinct saving to the user, as it means that more work can be done for the same gas consumption, or a monetary saving be effected on the work required to be done. Thus, although the cost of maintenance without a direct charge has to be borne by the price per therm, the consumer has a contra, and so is not actually affected, other than by his feeling of satisfaction. This being so, the policy of maintenance without direct charge is an excellent means of lightening the work of the department, and of developing business. However, in the second part of the paper, Mr. W. B. McLusky puts forward his plan for effecting, through the charge for gas, two objects—both extremely important. One is the equitable distribution of overhead charges among gas consumers; the other, a system of charge which will encourage the greater use of gas. It must be admitted that the flat rate charge, with discounts or rebates, has proved a failure in doing justice between all classes of consumers; and its application is very inefficient in promoting the consumption of gas per consumer. The increasing of consumption through each existing service-pipe is one of the best forms of reducing costs per unit of demand through that pipe. But the maximum possible demand through existing service-pipes will never be realized unless we have a more scientific method of imposing the charge due from each consumer, and which will give the consumer automatically a reduction of charge per unit, the greater the consumption becomes. The case which Mr. McLusky makes out against flat rates and discounts (which are arbitrary in their incidence) appears to be unassailable; and, upon the grounds of equity and of the application of a commonsense policy to charges (apart from realizing equality with our chief competitors), he gives the responsible men of the gas industry plenty of which to think. He has been convinced for the past

quarter of a century—and the conviction has hardened—that there is something wrong with the flat rate, and the simple appendage of a fixed discount according to volume; and he eventually became satisfied that a two-part scale of charges was the best form of serving equity and the promotion of demand through each service pipe. As he points out, under such a system no consumer gets a rebate or discount until he has discharged his obligations in respect of fixed charges. One of the features of the contribution is that it contains a compendious history of what has been done in this direction in connection with gas supply; and, while Mr. McLusky must be reckoned among the pioneers in this matter, he gives to Mr. George Anderson and Mr. Henry L. Doherty the credit for their first attempts to get upon a basis which would bring about a better relationship between charge and demand, having regard to the interests of the undertaking. Where, in our opinion, the electricity industry has, in most cases, failed in applying the two-part tariff is first in founding the fixed charge upon rateable value, and, in so many instances, in adopting the same percentage upon that value—as though there were no differences in rateable value and no differences in the requirements of premises. Furthermore, rateable value has no relation whatever to the costs involved in the provision of supply. What is needed is that each undertaking should make a proper valuation of zones of consumers, so as to get the overhead charges on to an equitable foundation. Mr. McLusky in his paper gives examples which show, in the circumstances of Halifax, the average consumption per consumer, works costs, and expenditure other than works costs. In the illustrative data, it is shown how the overhead charges per 1000 c.ft. in two towns are low for totally different reasons: In the one case, because the unredeemed debt is low, and, in the other, because the volume of gas sold per consumer per annum is high. The figures focus attention on the fact that the cost of production is of less value to the consumer than a large consumption per service-pipe. Of course, it is not suggested that the small consumer should pay a fixed charge levied on the average. In Halifax, the author claims that the overhead charges are distributed equitably between the small and the large consumer—the smallest householder paying a fixed charge of 39s. per annum; and the smallest industrial consumer £2 per annum. The highest charge for domestic purposes on the books of the undertaking is £9 10s. 8d. per annum; the highest for industrial or commercial purposes, £450 per annum; and for public lighting, £2240; while the price of gas to every consumer is the same.

In the Halifax scheme, Mr. McLusky appears to have catered for all demand purposes. There are alternative scales for commercial and industrial use, in one of which £2 per annum is charged per horse-power, or the equivalent (20 c.ft.), demanded, with gas supplied at from 2s. to 1s. 3d., according to consumption; and, under the other, consumers can pay a descending rate according to the volume of consumption for lighting and non-lighting purposes. The latter scale is also applied, if desired, to domestic consumption. But the greatest interest is evoked by the "standard requirements scheme" and the "two-part" system. The former is unique in that the quantity of gas charged at the ordinary price varies according to the size of the consumers' premises. The fixed standard requirement is 37½ c.ft. per annum per superficial foot of floor area of the living and reception rooms. The volume of gas so ascertained is charged at the lighting rate, and all gas in excess at the non-lighting rate. It should be noted that, in premises lighted mainly by electricity, the gas burners in use are separately assessed to arrive at the standard requirement for lighting purposes. In regard to the two-part system, in the paper will be found a scale of the fixed charges per quarter based upon the amount of standard requirements per annum. The scale starts at 9s. 9d. per quarter for a standard requirement of 9000 c.ft., and ascends by 1s. 1d. per 1000 c.ft. until, at a standard requirement of 24,000 c.ft., the fixed charge per quarter is 26s. The fixed charge meets all expenditure other than works cost. Under the two-part scheme, the gas consumed is charged at 2s. per 1000 c.ft for any quantity up to a million c.ft. per annum; and there are threepenny decreases in price for consumption between each additional million until 1s. 3d. per 1000 c.ft. is reached for consumption above 3 million c.ft. per annum. Coin meter supply is dealt with by charging 4s. 2d. per 1000 c.ft. up to 6000 c.ft. per quarter, and 3s. 9d. for all gas used in excess. Very small domestic consumers find it an advantage to continue on the flat rate. The effects of the different scales as presented in the paper will be closely examined. It will be seen that per 1000 c.ft., with a works cost of 1s. 6·73d., as the consumption diminishes, the amount available for all other expenditure increases. But is there sufficient variation in favour of the large consumer as compared with the small one? Take the industrial customer who uses 10 million c.ft. per annum—he only realizes an advantage of 1·15d. per 1000 c.ft. over the domestic consumer who uses 220,000 c.ft., notwithstanding that the former is a heavy day consumer, with his demand spread, we may assume, fairly equally over the twelve months. However, if the industrial consumers are satisfied, all the better. No doubt Mr. McLusky's justification is that the small consumer is a potential large user of gas; and it is among them that there is to-day the keenest competition by electricity to secure a heating and cooking load. But Mr. McLusky is able to tell us that the best customers of the Electricity Department are numbered among the largest users of gas for non-lighting purposes, in spite of the two-part tariff for domestic electricity supply. The proof of satisfaction with the scales of charges is that they have successfully appealed to the consumers. From his experience, Mr. McLusky believes that nothing but the present inequitable system of levying charges stands between the gas industry and a large increase in business. There are many other points of interest in this section of the paper. Appended to it will be found information regarding schemes which (since the Halifax one was developed) have been introduced in America, and are working admirably.

These contributions from Mr. John and Mr. W. B. McLusky are of the highest interest and importance to the gas industry in these times when it has to consider future stability and development in—not past, but current and still changing—environment. The service work at Glasgow and the charges system of Halifax contribute information which will help to guide (if not applied in precisely the same form) every gas administration to elements in the construction of a looking-ahead policy.

Developing the Outer Areas.

THE Government scheme of electricity supply, with its proposed concentration of generation, network of transmission and inter-connecting cables, transforming stations, and elimination of uneconomical and inefficient stations, has revived in the gas industry the question of doing more in the same way—not, however, in such an ambitious, capital absorbing and destroying manner, or with a novel compilation, above the industry, of official regulation and control as is designed for the electricity industry; but by all well-situated gas-manufacturing stations throwing out high-pressure distributing mains, so as to embrace or supply in bulk undertakings which are not rendering gas service which is to the credit and well-being of the industry. If every well-placed undertaking in the country engaged in enterprise of this character, so, by prevision, creating for itself a larger market for the future, it would at the same time be raising the standard of efficiency, economy, and reputation of gas throughout the land. We who reside in areas supplied by large enterprising concerns sometimes forget that the industry's claims to efficiency of production and of utilization, the cheapness of gas therms, and so forth, come before many people who live in different circumstances, and who in consequence may not, through their experience, believe that the claims are justified. That condition has to be met; and the best way to do it is by providing the justification of the claims in the areas in which these people reside. This supply of the outer districts is among the subjects which, in the looking-forward policy, is of current concern to the gas industry. For this reason hearty welcome is given to the highly interesting contribution on "The Distribution of Gas at High Pressure," which was made by Mr. Arthur W. Sumner at the Institution meeting—the matter being one in which he has had a large experience in his Essex territory.

We have previously been interested in what the Grays

and Tilbury Company have done in this direction; and what they have accomplished is an example of no mean importance. In the paper Mr. Sumner brings his experiences up to date; and their relation shows that underlying is a confidence that the Company did the right thing when, thirteen years ago, they commenced to carry out a policy which is strongly advocated to-day. In the intervening years they have played a large part not only in developing their own interests, but in promoting by an object-lesson those of the industry. Before territory annexation began, the Company had an area of 32 square miles, which is served by low-pressure mains; the added area comprises 130 square miles, which is supplied by high-pressure mains. It is true that on the scheme they have spent £24,645; but, through the high-pressure system, they have added to their roll 4965 consumers, to whom is delivered 119,626,900 c.ft., or 48 p.ct. of the total gas sales. In other words, they have in thirteen years almost doubled their business from their rural surroundings. The 130 square miles of added area comprise 37 parishes which were not receiving a supply of gas, and four parishes supplied by small gas-works whose aggregate annual sales were only 17½ million c.ft. That is the small nucleus to which over 102 million c.ft. of new business has been added. This is a fine illustration of enterprise and success.

An account is given in the paper of the elements of the high-pressure distributing system—the compressing plant, mains, governors, valves, and all accessories, together with much valuable information on points concerning them. The mains are 6 in., 4 in., and 2 in.; and many small extensions have been made, through the availability of gas, by 2 in. and 1 in. mains to minor villages; and now the total length of high-pressure mains of all sizes is approximately 60 miles—covering 22 parishes out of 41 in the added area. The technique of the various parts of the scheme is described by the author; and certain interspersed experiences inform as to matters which claim careful attention. For example, the house governors are fitted with leather seatings and a suitable vent-pipe carried outside the building to a place of safety. Such vent-pipes are no use blocked up. It seems that a few years ago wild bees found that they formed suitable habitations for them. Their choice of a domicile has been defeated by each vent-pipe being fitted with a reducing socket, the small end of which is connected to the vent; the large end being covered with a perforated zinc disc, with 195 holes to the square inch. Another difficulty experienced—it is described as the chief one—has been the slight accumulation of rust or foreign matter which is carried forward, and is deposited on the seatings of the governors—causing the vent in the house governor to blow, and the district governors to creep slightly during the hours of low consumption. To reduce the possibility of such accumulation, care should be exercised in seeing that all pipes are clean and free from internal corrosion before being jointed, and then be well blown out under good pressure before finally being put to work. To guard against the possibility of getting excessive pressure in the low-pressure mains due to the governors creeping, an electric bell is fixed in the residence of each depot inspector. This bell is brought into operation by the movement of a small column of mercury making contact and ringing the bell if the pressure rises above 8 in. It is these little details which contribute largely to success in such a scheme.

Data are given in the paper which show the results of pressure tests; also the cost of compression. The latter is among the points which gas engineers, in examining this subject, look at critically—almost, in some cases, with as much care as the capital charges involved by a scheme. Calculating that two-fifths of the steam raised on the works is required by the compressors, as 48 p.ct. of the gas made is distributed in this way, the cost of compression is 1·7d. per 1000 c.ft., or, with a calorific value of 460 B.Th.U., 0·37d. per therm, which is good running having regard to the size of the installation and the initial pressures, which in two tests were respectively 24 and 27 lbs. A point which, in the pre-calorific value days, used to arouse much suspicion when proposals were made for transmitting gas by high pressures, was the loss effect of the compression on illuminating power; but the concern has vanished with the coming of calorific value as the standard. Bearing on this point, a few peculiarly interesting figures are given in the paper. Some of these are from the reports of the Official Gas Examiner; the Gas Referees having prescribed a service from both the high and low pressure mains for official testing purposes. The figures prove how little the gas of the calorific value supplied is affected by compression. For the quarter ending December last, the average of the tests from the low-pressure main was 468·2 B.Th.U., and from the high-pressure mains, 468 B.Th.U.; and this was gas which had been compressed to 50 lbs.! A further range of consecutive tests shows that transmission does not affect the calorific value of the high-pressure gas. The first 28 tests are with the official calorimeter at Grays; and 26 tests, made some three or four hours later at Rayleigh Laboratory (18 miles away), show negligible variations from the Grays figures, with the result that there is parity between the Grays and the Rayleigh averages—viz., 465 B.Th.U. This is highly interesting. Costs are also given for cast-iron mains for low-pressure supply and steel pipes for high-pressure in the conditions of the Company. It must not be overlooked that, though the former shows an advantage in cost, the high-pressure steel mains deliver a great deal more gas, so that on a gas-delivery unit basis the latter are the cheaper. For protecting the life of steel mains, Mr. Sumner finds in most cases the usual coating and wrapping sufficient; but further protection can be afforded by a mixture of dehydrated tar and sand. In studying the figures regarding the comparative cost of services and fittings, it will be noticed that for high-pressure services the total cost is considerably more than for low-pressure ones; but the governor bulks largely in the constituent items. On the other hand, the governors ensure a constant pressure at the consumer's meter.

We agree with Mr. Sumner that the results achieved fully justify the Company in having adopted these plans for meeting the demand for gas by consumers who would not otherwise have the means of obtaining a supply, or such a cheap one. Moreover, having regard to the prospects and future interests of the Company, they confirm the wisdom of a policy, which, to the credit of the Company, has been so fully developed while others are still cogitating over it, and are not perhaps viewing it from all angles.

The Twenty-First.

The annual meeting of the Institution of Gas Engineers opened on the 21st of this month in the 21st week of the coal stoppage.

Place of Next Institution Meeting.

It has not yet been finally determined where the annual meeting of the Institution will be held next year. A cordial invitation to visit Nottingham was conveyed to the members through the President, Mr. John Wilkinson; but there seems to be a general feeling that it would be wiser to hold the business meeting in London, and, if arrangements can be made, for the excursion to be to the city in which the President carries on his professional activities. The Chairman of the Nottingham Corporation Gas Committee (Sir Albert Ball, J.P.) is an old friend of the gas industry, and is well known to numerous of its responsible men; and, therefore, we may depend that, if a visit is fortunately paid to Nottingham, there will be a warm-hearted reception there. However, nothing definite has been determined; but, in due course, the President and Council will settle the matter.

Miners' Federation Move.

The Miners' Federation rejected the proposals of the Premier to which reference was made in our editorial columns last week; but it was clear that, in view of the attitude of the Government, they were chary of doing anything which would definitely close the door to negotiations. With them it is now very much a question of self-preservation. After the Executive had pondered over the matter for the best part of two days, they indited a reasoned letter which was sent to the Premier. But their arguments showed that they were still as far off as

ever from giving adequate consideration to the changes in the fundamental trading conditions of the industry. Moreover, the coal owners are resolute over the necessity for district agreements, in the interests of the nation, and owing to the differences in the economic conditions of the various coal areas.

The Proposals.

The Miners' Federation also submitted to the Government a series of proposals as terms for a settlement. They suggested, first, that the miners should accept wages not less than those payable under the terms of the 1921 agreement (only as a temporary arrangement) for the immediate resumption of work. Secondly, that the terms of a national wages agreement should be referred for decision to an independent tribunal to be agreed upon by the parties. Thirdly, that the terms of reference by the tribunal should be the consideration, and application to the mining industry, of the recommendations of the Royal Commission. Fourthly, from the date fixed by the tribunal in respect of matters referred to them, every man affected by the award would be entitled by law to receive wages in accordance with the decisions. It became known towards the end of the week that the Government are satisfied that these proposals do not, in fact, constitute a possible basis of settlement which could be utilized to terminate the dispute. It is abundantly clear that the Miners' Federation, in the hope of securing a national agreement (which the owners refuse to entertain in any circumstances), are merely giving away as little as they possibly can; but their finesse will not obtain hold where business men are concerned. It was reported last Friday that a conservative estimate places the number of men now engaged in raising coal at roundly 100,000. We do not think this includes the safety men. One other item is that, according to Mr. Cook, nearly £900,000 has, since the strike began, been received from Russia; but that sum cannot have gone far among a million men, and spread over twenty-one weeks.

Summer Time Extension.

The coal strike has caused the suggestion that there should be a further extension of summer time. We fail to see that, by the end of the statutory summer-time period, there would be any saving value in this; and, moreover, as the time has been determined by Act of Parliament, it would require further legislation to provide for the extension. Next Saturday night, clocks and watches must be put back one hour.

Erratum.—In the last issue of the "GAS SALESMAN," p. 207, there was an article describing the new gas radiators made by Messrs. John Wright & Co. It was stated that these were "steam" radiators. This is an error; they are of the "steamless" type.

Wales and Monmouthshire District Institution.—A general meeting will be held at Porthcawl on Tuesday, Oct. 5, at 11.30, when the chair will be taken by Mr. H. D. Madden, the President. Mr. J. Stephenson, of Ferndale, will read a paper entitled "A Plain Tale from the Hills."

EAST GREENWICH WAR MEMORIAL.

Unveiled by Dr. Charles Carpenter.

A memorial in stone, inscribed with the names of 79 employees of the East Greenwich section of the South Metropolitan Gas Company who lost their lives in the war, was unveiled by Dr. Charles Carpenter, the President of the Company, and dedicated by the Bishop of Southwark, on Sept. 18. The memorial, a large rough-hewn block of granite, stands in a semi-circular recess in a wall at one end of a rectangular pleasure garden constructed by the Company in front of Blakeley Buildings, Tunnel Avenue.

The ceremony took place under the cover of a wide canvas awning, where accommodation was afforded for relatives of the departed, the Directors and other officers of the Company, the Metrogas Choral Society and the Metrogas Military Band, and members of the Greenwich Borough Council and other public bodies. The Rev. F. Challenor, Vicar of St. Andrew's, Greenwich, officiated.

Before the service opened Dr. Carpenter and Sir George Hume, J.P., M.P. (Chairman of the London County Council), inspected a guard of honour composed of about 50 members of the 302nd Company Anti-Aircraft Battalion, Royal Engineers (T.), who were formed up in front of the memorial under the command of two officers. The service then began with the singing of "O God, our Help in ages past," after which the officiant read the names engraved on the monolith.

The BISHOP OF SOUTHWARK said it was barely eight years since the guns ceased firing and peace was proclaimed, yet they had passed through thrilling changes which had engaged the attention of the statesmen of the world and had affected the lives and happiness of millions. Memory was short, and there was a danger lest the interest, the experience, and the excitement of the times should make them regard the war as an event of long ago, simply occupying a place in the pages of history. It was, therefore, only right that from time to time they should solemnly call to memory those who laid down their lives for a great and noble cause.

Among the officials of the Company present were Mr. F. McLeod (General Manager), Mr. F. Day (Secretary), Messrs. P. Richbell, C. H. Pelben, T. Curr, A. H. Andrews, E. V. Evans, F. A. Frost, and A. Stokes.

PERSONAL.

Lieut.-Colonel H. S. ATKINSON has been appointed Chairman of the Spenborough Gas Committee, in succession to Mr. J. H. Collier, who has resigned.

Mr. GILBERT MACFARLANE, Assistant at the Nelson Gas-Works, has been appointed Engineer and Manager of the Tipton Gas-Works.

Mr. HARALD NIELSEN, Engineer and Technical Consultant to Sensible Heat Distillation, Ltd., has been invited by the Carnegie Institute to read a paper on the production of primary oils from coal by the "L & N" process. The International Congress at which this paper is to be read has been arranged by Dr. Baker, the Principal of the Carnegie Institute of Technology, Pittsburgh, and is to be held there in the middle of November.

OBITUARY.

FREDERICK A. PYE.

Many friends and business acquaintances in the gas industry will hear with much regret of the death of Mr. Frederick A. Pye, which occurred at his residence at Rhyl on Sept. 21.

Mr. Pye was educated at the King's School, Chester, and on leaving school he joined the Chester United Gas Company, of which his father, Mr. James Pye, was Secretary. He was appointed Assistant Secretary and General Manager, and on the retirement of his father, twenty years ago, became Secretary. He was very well known in the gas industry, and took an active part in the Commercial Section of the Manchester District Institution of Gas Engineers. He was a member of the Executive of the National Gas Council, and served on the Committee of the British Commercial Gas Association. Under his régime the business of the Chester Gas Company developed in a remarkable degree. The business of the Company has practically trebled during his management.

Mr. Pye had a great deal to do with the organization of the Company's profit sharing scheme, which was founded in 1901; the Chester Gas Company being among the first provincial concerns in the industry to establish such a scheme. After the war the scheme was amended, and is now a co-partnership scheme.

Much sympathy is felt for his widow and his two sons and two daughters. His younger son, Mr. Harold Pye, is Assistant Works Manager to the Chester Gas Company.

FORTHCOMING ENGAGEMENTS.

Oct. 2.—WALES AND MONMOUTHSHIRE JUNIOR GAS ASSOCIATION.—Visit to Bath.
Oct. 5.—WALES AND MONMOUTHSHIRE DISTRICT INSTITUTION OF GAS ENGINEERS AND MANAGERS.—Meeting at Porthcawl.
Oct. 8.—NORTH OF ENGLAND GAS MANAGERS' ASSOCIATION.
Oct. 9.—WESTERN JUNIOR GAS ASSOCIATION.—Inaugural meeting at Bristol.
Oct. 25, 26, 27.—BRITISH COMMERCIAL GAS ASSOCIATION.—Annual conference at Newcastle-upon-Tyne.
Nov. 12.—SOUTHERN ASSOCIATION OF GAS ENGINEERS AND MANAGERS.—Meeting at the Hotel Cecil.
Feb. 16.—"B.C.G.A." MIDLAND DISTRICT CONFERENCE.

INSTITUTION OF GAS ENGINEERS.

Oct. 11.—EMERGENCY COMMITTEE. FINANCE COMMITTEE.
Oct. 12.—ADVISORY COMMITTEE ON EDUCATION.

WESTERN JUNIOR GAS ASSOCIATION.

In the past, a large number of those connected with the technical side of the gas industry in the West of England have not been favoured with facilities for the interchange of ideas.

A Junior Association having the above title has recently been formed. A number of preliminary meetings have been held, and the inaugural meeting of the new Association will take place at Bristol on Saturday, Oct. 9, and will be preceded by a visit to the Stapleton Road Works of the Bristol Gas Company. The meeting will take place at the Chief Office in Colston Street, when the officers and Council of the Association will be elected, and other matters discussed.

Every endeavour has been made to inform prospective members in the area, and a large number of applications has been received. If, however, any eligible persons have been overlooked, they are cordially invited to apply for membership to Mr. C. Bateman, of the Bath Gas Light and Coke Company, who is acting as Chairman of the Provisional Council.

Under the patronage of their Majesties the King and Queen, "Health Week" will be observed throughout the British Empire from Oct. 3 to 9.

NORTH-EAST COAST COAL TRADE.

From our Own Correspondent.

There is still no change in market conditions. There have been numerous inquiries from abroad; but collieries and merchants will not at present risk quoting for them, except, in rare instances, at very "safety" prices. They are, of course, equally unable to offer any loading date; those within the industry having no more idea when the strike may end than any one else. It is felt, however, that if the end is to come by means of a gradual drift back, Durham and Northumberland will be among the last. As exporting districts, the terms they can offer are not as good as most of the others, and prospects, except perhaps for the first few weeks, have certainly not been improved by the play that competitors have had with our markets for five months.

COAL TRADE IN THE MIDLANDS.

From Our Local Correspondent.

The principal development is a sharp rise in pit-head prices. It is not a general advance; but the lead given by a few collieries has been followed by a number of others. The coalowners concerned deny that they are exploiting the shortage of the market. They declare that the prices hitherto charged were not in fair proportion to the greatly increased cost of getting coal and maintaining the properties under the conditions which now prevail. The advances range from 2s. 6d. up to as much as 7s. 6d. All grades now being marketed are affected. D.S. nuts, the demand for which greatly exceeds supply, fetch as much as 45s., and slack 20s. to 30s., at the pits.

The Birmingham Corporation, after advancing their coke price to 54s. 6d. in carts and 56s. 6d. in bags, and reducing the quota of the trade to 25 p.ct., have withdrawn supplies altogether except for essential services. Consumers in the metallurgical industries are, however, in a more favourable position, thanks to increasing arrivals of Continental coke. Shipments are so much larger that prices have moderated appreciably. Industrialists are disappointed at the limited assortments with which they have to make shift. They had hoped the example of those collieries in the district which reinstated full screening operations would have been widely followed; but in very few cases is more than one screening given. Managers say it does not pay to do more with the relatively small output they are making. Householders are getting more solicitous concerning winter supplies, and the hardening tendency of prices.

YORKSHIRE AND LANCASHIRE COAL TRADE.

From our Local Correspondent.

The continuance of the stoppage naturally creates increased difficulties, although public utility works are being well served in respect of supplies. Cargoes of good American gas coal continue to arrive daily, and are being apportioned to the various works, which have only a few weeks' supplies in hand. Prices are firmer, with slightly higher tendencies for prompt delivery, although there are indications that for forward business some reductions will be made.

CURRENT SALES OF GAS PRODUCTS

The London Market for Tar, Tar Products, and Sulphate.

LONDON, *Sept.* 27.

The prices of all tar products continue firm. There is a growing demand for pitch, and the price to-day is between 130s. and 140s. per ton at makers' works, with very little available.

Creosote also is in short supply, and the price is a matter for negotiation; but the value is certainly not below 8d. per gallon at **makers' works.**

Tar spirits continue firm at about 2s. 3d. per gallon for 95/160 solvent naphtha, 3s. 6d. per gallon for pure toluole, and 3s. per gallon for pure benzole.

Tar Products in the Provinces.

Sept. 27.

The markets for tar products have remained fairly steady throughout the past week.

Owing to the continuance of the coal strike improved prices have been paid for pitch for October/December and January/March shipments.

The average values of gas-works products during the week were: Gas-works tar 85s. 6d. to 90s. 6d. Pitch, East Coast, 120s. to 122s. 6d. f.o.b. West Coast—Manchester, 112s. 6d. to 115s.; Liverpool, 115s. to 117s. 6d.; Clyde, 118s. 6d. to 120s. 6d. Benzole, 90 p.ct. North, 1s. 11d. to 2s.; crude, 65 p.ct. at 120° C., 1s. 4d. to 1s. 5d., naked at makers' works; 50-90 p.ct., naked, North, 1s. 11d. to 2s. Toluole, naked, North, 1s. 11d. to 2s. nominal. Coal-tar crude naphtha, in bulk, 9d. to 9¼d. Solvent naphtha, naked, North, 1s. 9d. to 1s. 10d. Heavy naphtha, North, 1s. 1d. to 1s. 2d. Creosote, in bulk, North, liquid, 8d. to 8¼d.; salty, 7¼d. to 7⅝d.; Scotland, 7⅜d. to 7⅝d. Heavy oils, in bulk, North, 7¼d. to 7⅜d. Carbolic acid, 1s. 4d. to 1s. 5d. prompt. Naphthalene, £11 to £14; salts, 90s. to 100s., bags included. Anthracene "A" quality, 2½d. per minimum 40 p.ct., purely nominal; "B" quality, unsaleable.

Dorking Gas Company.—The accounts of the Company for the half-year to June 30 show (after providing for interest on debenture stock) a balance available of £3920; and the Directors recommend the payment of dividends at the rate of 10 p.ct. per annum on the "A" and "B" shares, 7 p.ct. per annum on the "C" shares, and 5 p.ct. per annum on the "D" shares. This will leave a balance of £2145 to be carried forward.

INSTITUTION OF GAS ENGINEERS.

ANNUAL MEETING,

AT THE

INSTITUTION OF CIVIL ENGINEERS, GREAT GEORGE STREET, S.W.

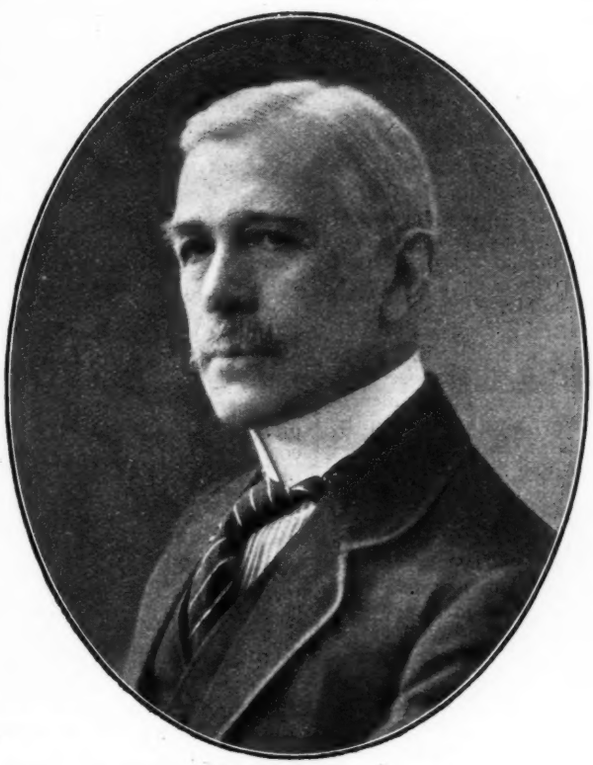
SEPT. 21, 22, and 23, 1926.

President: CHARLES F. BOTLEY, Esq., M.Inst.C.E.

REVIEW OF THE PROCEEDINGS.

[A Verbatim Report is given on later pages.]

THE meteorological prophets predicted that the opening day of the Institution meeting would be "From fair to fine." We cannot dispute that the day was fair, though there was little of the sunshine that helps to gladden the hearts of men. But despite all the stress and strain through which British gas engineers have been passing during the past five months, in providing gaseous and other smokeless fuel for a country which, during most of that long period, has been destitute of production of the crude material, we found among the men who greeted us from all parts of Great Britain and Ireland the same sunshine and cheeriness to which we have been accustomed for long years. Gas engineers and managers have had many big difficulties to face, and have overcome them. This coal stoppage is the biggest they have ever been called upon to encounter, and they have met it with fine verve. This, naturally, has been mixed with an amount of anxiety, and yet there has been cheerfulness borne of confidence that they would not fail their constituents. So, also naturally, the great topic of conversation outside the meeting was the experience of the last few months. And all, through their prevision and acumen, have been doing very well, even after stocks got low, and recourse had to be made to imported coal.



CHARLES F. BOTLEY, M.Inst.C.E.

There were many well-known faces missing from the meeting—solely through the state of emergency. Surprise was that so many had made it possible to be in London for the business and technical proceedings of the Institution. This, however, only illustrates again how thoroughly and successfully gas engineers tackle the job—however troublesome it may be—that they have in hand. At the opening of the proceedings, it looked much as though there would be a somewhat attenuated assembly; but many of the members within reasonable distance of London had left their journey thither for the Tuesday morning, and succeeded, by the time the President (Mr. Charles F. Botley, M.Inst.C.E., of Hastings) rose to deliver his supplementary address, in filling the seating accommodation of the smaller hall, at the Institution of Civil Engineers, which was occupied on this occasion.

Visitors from Abroad.

Among the visitors noticed from abroad was Mr. Arthur Hewitt, of Toronto; Mr. H. V. Mitchell, of Brighton, Victoria, Australia; Mr. Friederich Lux and Mr. Alfred Huber Ruf, from Germany; Ing. B. Rosenbaum, from Austria; and Mr. Vladimir List, from Czecho-Slovakia. A very hearty welcome was given to the visitors from overseas.

The Business Meeting.

Accompanying the President on the platform were many well-known faces in the gas industry. The Council were represented in good strength. The President-Elect, Mr. J. Wilkinson, of Nottingham, was there; and our old friend Mr. W. E. Price, Hon. Secretary of the Institution, hale and hearty as ever. There was that paragon of a Secretary, Mr. Walter T. Dunn. Sitting at the President's right-hand side was the Chairman of the Hastings and St. Leonards Gas Company, Mr. William J. Glenister, who followed the whole proceedings with the obvious interest of one who, when he takes a matter in hand, likes to hear and learn all he can about it. Abstruse chemical problems and constructional technical details apparently were not repulsive to him, for he followed the speakers throughout with an evident desire to imbibe as much as possible of their knowledge. During the early proceedings, Mr. Glenister bore testimony to the great respect in which Mr. Botley is held by his Board and by the customers of the Company. He also feelingly referred to the courageous way in which the President had met the difficulties of the times, the claims his high office in the Institution made upon him, the while was with him the grief of a great domestic affliction.

Personal Matters.

Mr. George Evetts had a very enthusiastic welcome when he was called by the President to receive the H. E. Jones Gold Medal for the notable paper which he submitted to the Institution last year, on "The Economics of Gas Production on the Thermal Basis." The skill and

perception embodied in that communication were recognized not only by the Council, but by the members generally. It outstandingly justifies the selection by the Council for the bestowal of the medal this year; but there was the further appropriateness, which was mentioned by the President, that for many years Mr. Evetts had studied under, and worked with, our revered late friend, Mr. H. E. Jones, whose beneficence made it possible for the Institution to hand a medal to the author of the contribution in any one year which, through super-merit, deserves it.

The diplomas to the successful candidates in the Gas Engineering Examinations were personally handed to those who were fortunate enough to be able to be present at the meeting. The honours gained by them were also thoroughly recognized by the warmth of the applause.

Next came the conferment of honorary membership upon the Presidents of several Gas Associations in other countries. On this occasion, welcome was given to the inclusion of the President of the German Association; and this restoration fitly coincides with the admission of Germany to the League of Nations. During the proceedings, the President announced that Mr. De Brouwer, the President of the Belgian Association, had cabled the best wishes of that organization for the meeting, and prosperity to the Institution. A message has been sent reciprocating Mr. De Brouwer's kind sentiments.

A Great Achievement.

Interest was next aroused by the President proposing that Mr. H. C. Honey, the first Director of Gas Administration under the Gas Regulation Act, should be elected an honorary member of the Institution. In eloquent terms, the President placed on record the views of the Institution regarding the splendid spadework Mr. Honey did in connection with the inauguration of the Act. Everyone who had come in contact with him in his official capacity learned to respect him and his decisions. The honour which had been done him was acknowledged by Mr. Honey; and his words were happily framed. For the greater part of his life, he has been a public servant; and therefore, as he said, he is perfectly at home in an assembly composed also of servants of the public. He recalled prominent men of the industry who have passed away, and with whom he had been brought into contact during his official life—Sir George Livesey, Sir Corbet Woodall, Mr. Harry Jones, and others, whose work abides. He referred to the happy relations with living members of the gas industry. Mr. Honey's interest in the industry, though he has relinquished official work, still continues. The surveillance which he has so long been accustomed to maintain over the affairs of the industry appears to be an inseparable part of his nature; and he has been making observation of how the industry has maintained its responsibilities and service during the protracted coal stoppage. He congratulated it upon the position it has won in the country. As he remarked, this is not the first great national emergency in which the industry has played a dominant part, and once again it has shown itself a system of the highest national importance. He rejoices to think it has played such a noble part in keeping the country going during the lamentable strike. What it has done, has been eminently in the national interests. It is a great achievement.

Supplementing the Address.

It will be remembered that the President (in view of the postponement of the annual meeting) determined to circulate and publish his address at the time originally fixed for the meeting. There was much appreciation of this on the part of the members. The publication was wise, in view of the changes in the position of affairs. On this occasion, the President supplemented the address [see "JOURNAL" for June 9, p. 513] by comments on current affairs relating to the work of the industry. What he had to say is published *in extenso* on a later page. Naturally his first words referred to the great coal stoppage, the duration of which it had been impossible for anyone to measure or foresee. He asked the pertinent question, Of what benefit can it all be? There can be no benefit to anyone where nothing but loss obtains. He claims very properly that our industry (in common with other public services) deserves the congratulations of the nation upon the maintenance of its gas service, on which such a large number of people depend. The ability to do this is owing to the preparation that had been made by the industry with the prospect before it of a dispute with factors in it of irreconcilable nature through the obstinacy of, at any rate, one of the parties concerned. No one could have anticipated that the miners would be so indifferent to all interests save their own. However, as the President says, failures of gas have been few; and such as there have been, were due to political causes. He also referred to the remarkable work which has been done in dealing with the import of foreign coal. There will be agreement with him that intervention of the Government has been somewhat unfortunate; every move on their part having been made an excuse by the leaders for advising the men to continue their resistance to anything opposed to the policy of the Federation. There is approval on his part with the legislation which allows the hours of working in the mines to be more flexible.

The President passed in review other recent happenings such as the establishing by the Government of the Fuel and Power Committee, and the Committee to consider the co-ordination of coal selling. Mention was made of the new organizations dealing with fuel technology, and of their complexity. In his view, there should be close co-operation between those dealing with fuel technology and the bodies representing large users of fuel. The Institution are proposing to take part in the coming symposium, and in the other activities concerning fuel, and the provision of the smokeless varieties. Acknowledgment was made of the beneficial work of the Fuel Research Board; and attention was directed to the investigation regarding the development of a greater flexibility in gas manufacture by the injection of oil in vertical retorts. The work in this connection is to be continued; and there is hopefulness regarding future development. There was allusion to the uncomfortable experience of those who have been relying upon coke-oven gas for the provision of part of their supply. The production of economies by the use of waste-heat boilers is now accepted practice in the gas industry. In connection with the involved question of laying pipes in highways and the diversion of existing pipe-lines, the President referred to the advantage of close co-operation between highway authorities and the users of the sub-soil of roads. The development of coal and coke handling plant came in for mention, together with the big subject of the improvement of gas coke, with the view of making it a more approved material for all purposes for which it is suitable. The present trend of matters in connection with the desire for a purer atmosphere should extend coke in public favour—if the commodity itself is properly handled. Mr. F. P. Tarratt, of Newcastle-upon-Tyne, and Mr. J. W. Napier, of Alloa, appropriately voiced the feelings of the meeting regarding the careful survey made by the President in both his original address and the appendix.

Help the Benevolent Fund.

The Annual Report of the Council has already been published; and it was adopted without discussion.

There was an innovation on this occasion by introducing at this point consideration of the report of the Benevolent Fund Management Committee as part of the proceedings, instead of, as formerly, dissociating it from the ordinary business by holding a separate meeting—usually on Wednesday morning. The report of the Committee was given in our issue for June 2, p. 462. From the remarks which were made by the President, Mr. J. Ferguson Bell, and Mr. C. S. Shapley, it is clear that there is still cause for some dissatisfaction in respect of the lack of support of the fund by some members of the Institution. There is a desire to get everybody to subscribe, even though ability only permits of a small sum being given annually. As the President observes, it is not the few who should give liberally; it is the many who should give as they can. He desires that the contribution to the fund should make it absolutely independent of the proceeds of the invested moneys in order that the investments may be, if possible, accumulated against such times as there

may be more pressing demands for assistance to deserving cases.

Education in the Gas Industry.

The next matter to engage attention was the report of the Committee on Education. The document itself is given in full elsewhere; but it was succinctly outlined by the Chairman of the Committee, Mr. F. W. Goodenough.

The report shows the year to have been one of steady progress and development. The facts that seven additional technical institutes have had courses in gas and ancillary subjects approved during the year, and that the number of candidates for examination in 1926 has increased to 162, compared with 108 in 1925—an increase of 50 p.ct.—are evidences of this. Considering the needs of the industry, however, the Committee very rightly are not satisfied with the present condition of affairs, and state that one of the problems the industry has to solve is how to ensure a regular flow of students in the numbers which

F. W. GOODENOUGH, C.B.E.

its future welfare demands. To our mind this can best be accomplished by making promotion dependent far more than at present on the acquisition of technical knowledge, and by encouraging success by increases in pay. Generally speaking, a man does not study the problems of gas manufacture, distribution, or sales for the inherent joy of this work. There is equal pleasure to be found in studying the technicalities of most other industries; and if this enables him to develop more, and thus become a greater potential source of help to his fellow men, he can only be complimented on the good sense which prompted him to adopt it. If an industry demands capable men, but is unwilling to give them their worth in relation to other industries, it will certainly vociferate in vain, and at best will have to remain in the back row of the pit in the theatre of progress. A great deal of excellent work has been accomplished by those who have assisted in making the Education Scheme of the gas industry the success it is. Now that the scheme has been so firmly launched, the rate of increase of its value will doubtless be one of uniform acceleration.

It is clear, from what Mr. Goodenough says, that we must not be impatient over the results of the scheme. It is one of those things which, being new to an industry operating throughout the land, must undergo gradual development both in its mechanism and in its results. It has to be remembered that we are still in the early stages of the scheme, and that to take the full course of training absorbs a considerable period. It is, so to speak, that initial period through which we are passing. We are not, therefore, at all disappointed with the number of candidates who have already submitted themselves for examination under the scheme; more will follow as the educational work flows on. As a beginning, what has been done is highly encouraging. From what Mr. Goodenough said, we are inclined to think that he himself is not disappointed with the results so far achieved. As a matter of fact, he says that the past year has been one of steady progress—not so great as might have been hoped, but still sufficient to be encouraging. Moreover, the scheme has during the past year been modified in certain particulars, without affecting principles, or lowering its standard; and modification can continue, if needed, with a view to giving to it greater elasticity, and improving its service to the industry. Our Scottish friends made it clear that they would like some provision to be effected to give more of their younger men better chances to obtain the full rewards of the examinations, in view of the insufficiency of suitable technical institutions. We rather fancy that until this matter is dealt with to the satisfaction of our friends in Scotland, they will not allow it to rest.

The Fifteenth and Sixteenth Reports.

The President announced that the Council had decided that the Fifteenth and Sixteenth Reports of the Gas Investigation Committee should be taken together. This decision (though the reports have no relation one to the other) was apparently come to owing to the work dealt with in the Fifteenth Report being more or less of a preliminary nature; but the future will see in this connection what we believe will be considerable and valuable developments. The Research Chemist who has this work in hand is Mr. James W. Wood, M.Sc. (Tech.), A.I.C., with Mr. G. B. Howarth, M.Sc. Gas Engineering (Leeds), A.I.C., as assistant. The scrupulous care they are taking in approaching the work was duly acknowledged. The subject of the investigation is

Carbon Monoxide and Gas Appliances.

The first part of the report deals with the methods of testing, and the second part with tests on gas-fires. The investigation has the excellent object of arriving at data on a subject concerning which it is easy to make mistaken statements, and of informing the gas industry as completely as possible on the hygienic and thermal position occupied by gas-burning appliances. The iodine pentoxide method for the determination of carbon monoxide is examined critically, and full details are given of the exact procedure adopted. It is stated that an accuracy of one or two parts per million can be realized in the determination of carbon monoxide in the products of combustion, provided the amount of carbon monoxide is small (less than 50 parts per million). Larger quantities can be determined with an accuracy of $\pm$ 2 p.ct.

Two gas-fires were used for the tests, one an up-to-date nine-radiant model, the other a typical ten-radiant fire made in 1911. The former was adjusted for a gas rate of 38·3 c.ft. per hour, the latter for a rate of 42·6 c.ft.; the gas used being a mixed coal gas and water gas, having a calorific value of 470 B.Th.U. The average production of carbon monoxide by the modern fire was 0·44 p.ct. of the gas burned; the rate of production being c.ft. per hour. When the gas consumption recommended by the makers was exceeded, the amount of carbon monoxide increased rapidly, and at 43·7 c.ft. per hour reached a value of 1·18 p.ct. of the gas burned. Below the normal consumption, the rate of carbon monoxide decreased. Regarding the pre-war fire, when the recommended gas consumption was exceeded, the amount of carbon monoxide in the products of combustion increased rapidly. At a gas rate of 44 c.ft. per hour—only 1·4 p.ct.

THE GAS RESEARCH STAFF.

Reading from left to right:—
Top Row.—C. B. Marson, M.Sc., A.I.C.; H. Kerr, A.I.C., Research Assistant; G. B. Howarth, M.Sc., A.I.C., Research Assistant; A. C. Monkhouse, Ph.D., B.Sc., A.I.C., Research Assistant.
Bottom Row.—J. W. Wood, M.Sc., A.I.C., Research Chemist; J. W. Cobb, C.B.E., B.Sc., F.I.C., Livesey Professor; A. Parker, D.Sc., F.I.C., Research Chemist.

per hour more than that recommended—it had reached 5·6 p.ct.

It is stated that at no time during the tests has it been possible to detect any escape of either carbon monoxide or other products of combustion into the room; and it is concluded that these are effectively removed by the flue. There is definite assertion that, though the amounts of carbon monoxide evolved by modern gas-fires are minute, there is sufficient quantity produced to justify the continuation of what is current good practice—that all fires should communicate with efficient flues.

At the end of the report are the results of a number of tests carried out to complete the aeration investigation of the Thirteenth Report. The experiments were made on a 1000-C.P. high-pressure lamp; and the results show at what aeration, under the conditions of test, the best illumination is attained.

The Sixteenth Report of the Committee deals with

Influence of the Size of Coal in Carbonization.

This is the first detailed study, in a systematic examination, of the influence of various factors on carbonization. The Committee are of opinion—and this view will be shared throughout the industry—that quantitative knowledge concerning these factors is essential to proper progress. To enable the required data to be obtained, Dr. Parker and his assistants (Mr. Kerr and Dr. Monkhouse) designed a modification of the horizontal unit of the Corbet-Woodall experimental plant, which arrangement (consisting of a "cronite" retort, and a new condensing system) facilitated exact control of temperature—a feature of primary importance. So far, the factor which has been studied is that of variation in the size of coal carbonized. One coal only has been taken in hand; other coals and factors will be investigated in turn. Quantities of gas evolved at successive stages of the carbonization with the different sizes of coal were noted, with the accompanying tar and coke; and special attention was given to the structure of the resulting cokes.

The coal used throughout the experiments was obtained from Nottinghamshire. Five grades of it were prepared. The largest passed through a screen 1¼ in. mesh, but remained on a ¾-in. screen; the limiting sizes of the smallest were 10 mesh and 30 mesh. When these various grades were submitted to a 2¾-hour carbonization at a temperature of *circa* 977° C., it was found that the thermal value of the gas made per ton of coal rose from 72·3 therms (gross) with the largest size to 75·8 therms with the smallest. This increase, it is suggested, is due largely to greater secondary decomposition of tar; for in the five tests mentioned there was a gradual reduction in the yield of tar from 8·3 to 6·2 gallons per ton of coal.

In the early stages of carbonization, the rates of gas production were greater with the larger sizes of coal than with the smaller. For example, the volume of gas made when the carbonization had proceeded for one hour decreased from 123·4 c.ft. with the 1¼ in. to ¾ in. coal to 108 c.ft. with the 10 to 30 mesh grade. The rates of gas production then became greater with the smaller sizes than with the larger sizes, until at the end of the carbonization period—*i.e.*, 2¾ hours—the total volumes of gas evolved from the smaller grades were greater than from the larger ones.

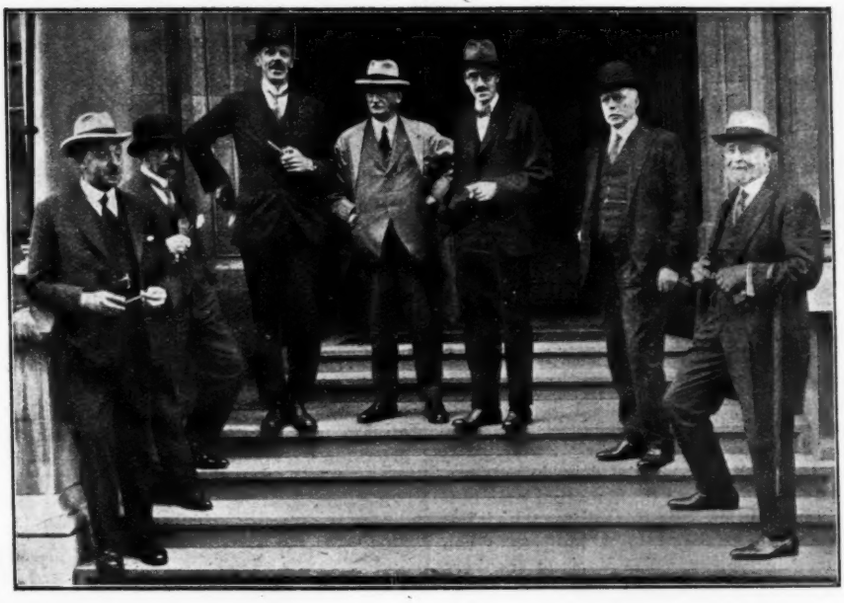
Experiments were conducted to determine the effect of altering the temperature of carbonization by about 25° C.; and a considerable increase in the rate of gas evolution was produced in the early stages of carbonization by raising the retort temperature from 977° to 1000° C. The figures given in the report indicate the importance of accurate temperature control. The structures of the cokes produced were subjected to micro- and macro- examination; and it was found that the coke from the 10 to 30 mesh coal was more uniform in structure than were the cokes from the larger grades. Moreover, in the former the walls of the larger cells contained a greater number of very small pores—a condition which makes for high reactivity.

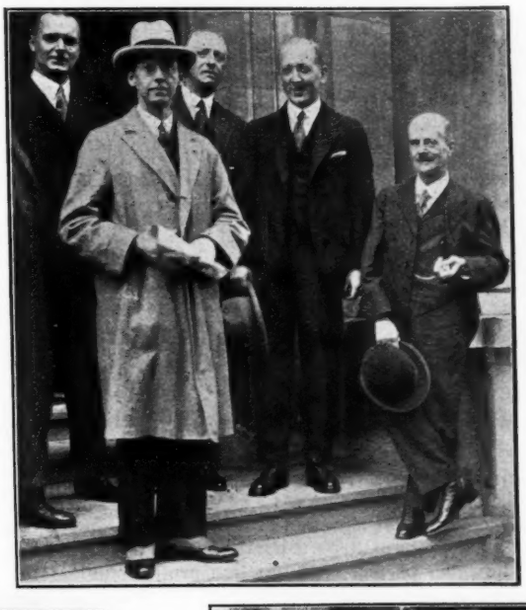
Compliment and Corroboration.

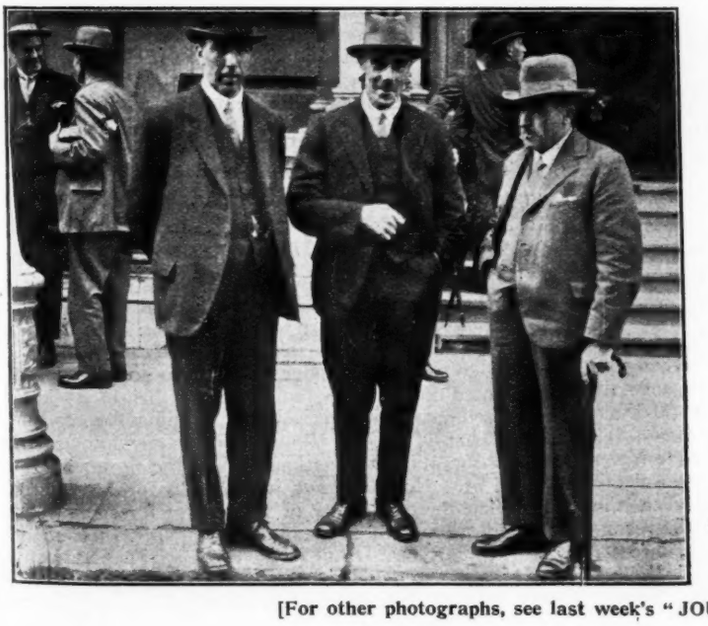
The reports were introduced by Prof. Cobb, who complimented the Research Chemists and their assistants upon their conduct of the investigations. He alluded to the preliminary nature of the Fifteenth Report, of which Mr. Wood subsequently described the chief features.

Dr. Parker also summarized the points arising from the research which he has had in hand. Of course, it will be appreciated that the retort used has been designed for these experiments with a view to securing at will an absolute uniformity of conditions, according to requirement. As Dr. Parker says, what they are out for in this investigation is fundamentals, and not to supply something

A FEW MORE SNAPSHOTS.







[For other photographs, see last week's "JOURNAL," p. 647.]

which can be reproduced in practice. Dr. Lander gave an account of work that has been proceeding at the Fuel Research Station with different sizes of coal, but working at much lower temperatures. Working at round about 600° C., they have not had any cracking of the tar oils; but, having regard to the difference in temperature, he traces corroboration of their results in the work described in the report. Mr. J. P. Leather and Dr. Weyman made contribution to the discussion.

Co-Operation—The Coal Strike.

After the morning sitting, the President and Council entertained at luncheon at the Savoy Hotel those who are taking a prominent part in the meeting, together with a number of professional and other friends. Important speeches were made in proposing and replying to toasts; and throughout there ran the view that in the best interests of individual professions and industries, there should be the largest possible measure of co-operation. Particular point was made of closer relationships being established between the gas and the electrical industries, and that both should endeavour, not infringing their liberty in fair competition, to do all that can be done in cultivating such relationships as will serve both mutual and national interests. It is hoped the Joint Committee which has been instituted will serve this end. A high tone ran through what was said in this regard. Various speakers also alluded to the great part the gas industry has taken in maintaining the means of heating during the prolonged coal stoppage. Mr. P. W. L. Ashley, C.B., the Principal Assistant Secretary of the Industries and Manufactures Department of the Board of Trade, particularly made eloquent acknowledgment of what the industry has done in this respect. His remarks will be read and prized, showing as they do that the Board of Trade keenly appreciate the fact that the industry has fulfilled its obligations, and has worked with wonderful determination for the benefit of the country, during the great emergency. The speeches at the luncheon will be found reported on subsequent pages—they are worth reading.

At the afternoon sitting, the contribution under consideration dealt with

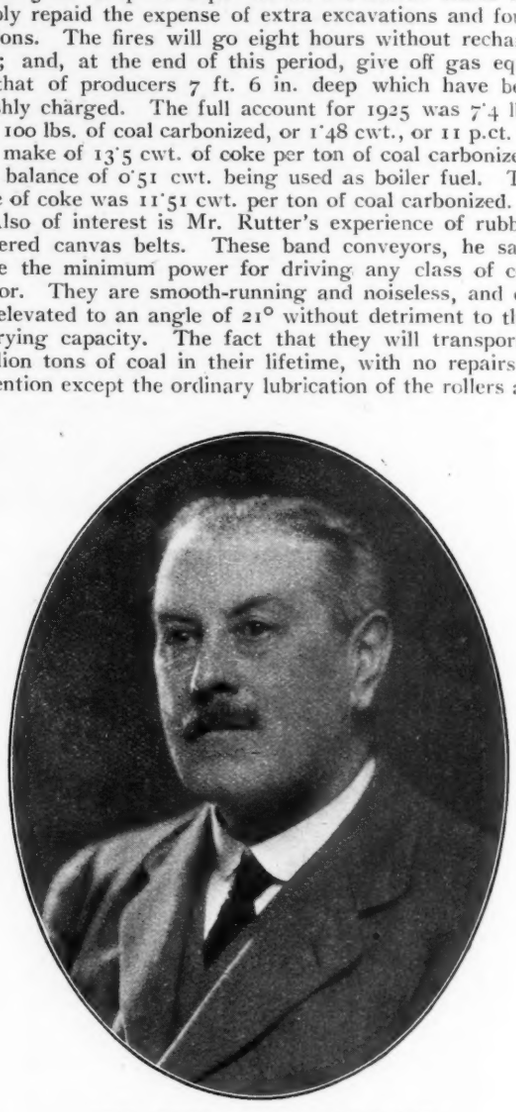
Reconstruction Work at Portslade.

It can be said without any qualification that in every phase of their activities the Brighton and Hove General Gas Company are thoroughly efficient. Considerable prominence has of late been given in the "JOURNAL" to their distribution system, their admirable maintenance scheme, and their excellent showrooms, by means of which the Company ensure that satisfaction among their consumers which makes for further business. But no distribution system, however perfect, can function properly unless the gas which has to be delivered to the consumer is of constant quality, and in volume always adequate to meet the growing demands. For this reason the paper by Mr. C. H. Rutter, on the development and reconstruction of the Portslade Gas-Works, was greatly appreciated.

The original works at Portslade were built in 1870-71, and had a gas-producing capacity of 300 million c.ft. a year. Development and reconstruction have increased this to 8 million c.ft. of coal gas and 7 million c.ft. of carburetted water gas a day. The author mentions that the Company were among the first half-dozen in England to instal carburetted water gas plant. This they did in 1895; the capacity of the plant being 1½ million c.ft. This method of gas manufacture proved so economical with the then low price of gas oil that further extensions were made in 1899 and 1901, which for the time stopped all enlargements of the coal carbonizing plant. Owing to the war, enlargements of the latter were in abeyance till after the Armistice, since when, however, the work of extension has been continuous.

After a brief description of the alterations made to No. 1 retort house, Mr. Rutter goes on to consider in detail the many improvements which were effected when the carbonizing plant in No. 2 retort house came to be reconstructed in 1922; and there are many features of interest and novelty in the design of the settings then installed. Special attention was paid to the placing of the bottom retorts with a view to efficient heating, which in many settings is a difficulty. To that end, they are positioned nearly central horizontally with the centre line of the combustion chamber, and well above the point of ignition. A feature of considerable interest is that the producer is 12 ft. 5 in. deep—a depth which the author states has amply repaid the expense of extra excavations and foundations. The fires will go eight hours without recharging; and, at the end of this period, give off gas equal to that of producers 7 ft. 6 in. deep which have been freshly charged. The full account for 1925 was 7·4 lbs. per 100 lbs. of coal carbonized, or 1·48 cwt., or 11 p.ct. on the make of 13·5 cwt. of coke per ton of coal carbonized; the balance of 0·51 cwt. being used as boiler fuel. The sale of coke was 11·51 cwt. per ton of coal carbonized.

Also of interest is Mr. Rutter's experience of rubber-covered canvas belts. These band conveyors, he says, take the minimum power for driving any class of conveyor. They are smooth-running and noiseless, and can be elevated to an angle of 21° without detriment to their carrying capacity. The fact that they will transport a million tons of coal in their lifetime, with no repairs or attention except the ordinary lubrication of the rollers and



CHAS. HERBERT RUTTER, M.Inst.C.E.
Engineer and General Manager, Brighton and Hove General Gas Company.

idlers, is a recommendation greatly in their favour. The paper concludes by giving a schedule of the approximate cost of the more recent alterations and additions.

Fuel Account and Other Points.

There was really no criticism of the paper; but it was suggestive to Mr. W. M. Carr, Mr. C. Dru Drury, Mr. G. M. Gill, Dr. Parker, Mr. J. W. Buckley, Mr. W. W. Atley, and the President—all of whom (as the full report of the discussion will show) found several practical points on which to comment. There was a good standard about the discussion. Mr. Carr told us why he finds there is a good case for the use of shield tiles with segmental silica retorts—at any rate, under the bottom joints. He also commented upon the low fuel account at Brighton—in fact, he finds difficulty in precisely ascertaining fuel consumption. That is an old trouble—one rarely knows, when fuel consumption is mentioned, how the figure has been arrived at. He also gave justification for Mr. Rutter's claim that there is plenty of waste heat for steam-raising in connection with horizontal settings. Interest was shown by Mr. Dru Drury in the reinforced concrete stage-floors; and he gave an excellent character to silica retorts both as time savers in carbonization, and for their

strength. Deep producers have also favour with him. Among other points, Mr. Gill emphasized the importance of making a good quality of producer gas, inasmuch as modern carbonization practice shows that more important than thermal yield of gas per ton is thermal yield per retort per twenty-four hours. He believes this has a great bearing upon cheap gas. Mr. Gill, Dr. Parker, and the President had also something to say concerning Mr. Rutter's fuel consumption. In agreeing with Mr. Carr as to the provision of shields, Mr. Rutter incidentally mentioned that he is perturbed by the behaviour of silica if any iron comes in contact with it. The slightest trace of iron has a very detrimental effect on the silica. As to the fuel account, their experiments at Brighton have shown that 13·5 cwt. of coke from the Durham coal used at Portslade is a fair average figure to take; and all calculations are based upon it. He also stated that the price of rubber belt conveyors is now about half what it was when they put in the one described in the paper.

Carbonization in Continuous Verticals.

"An Investigation of Some of the Factors affecting Carbonization in Continuous Vertical Retorts" was the title of a contribution by Mr. T. F. E. Rhead, Chief Chemist to the Birmingham Corporation Gas Department, which claimed consideration first thing Wednesday morning. Birmingham possesses a splendidly equipped coal testing works, which was erected in 1905, and has proved most valuable. At present the test carbonizing plant—which has a capacity of 250 million c.ft. a year, and the results of which are therefore representative of actual works' practice—consists of a bench of four beds of modern horizontal through retorts (capacity 36 tons a day) and a setting of Woodall-Duckham continuous verticals (capacity 20 to 24 tons a day) reconstructed in 1925 on the then latest model. One retort of the latter setting was isolated, and a thorough investigation on some of the factors influenzing carbonization results was carried out.

As a result of this work, the author states in no uncertain terms that good governing and proper supervision of heats are of vital importance in obtaining the best efficiency in working, and in extending the life of the plant. Variation in coal size leads to variation in porosity of the charge; and this causes serious fluctuations in results. Two typical screened gas coals were used for the tests. One was a slightly swelling coal which gave 70 therms of 550 B.Th.U. gas, 12·8 gallons of dry tar, and 35 gallons of 10-oz. liquor in horizontals; the other was a rich highly-swelling coal which gave 76·8 gas therms of 550 B.Th.U., 12·5 gallons of dry tar, and 27·5 gallons of 10-oz. liquor in horizontals, under the same conditions. Tests were made on the former coal graded to pass a $2\frac{3}{4}$-in. and stay on a $1\frac{1}{4}$-in. screen—*i.e.*, containing no smalls or fines below $1\frac{1}{4}$ in.—and on a further quantity of this sized coal after passing it through a breaker, which crushed it so that 90 p.ct. passed through a 2-in. screen, and contained a considerable percentage of fines.

The author states that the slightly swelling coal containing no fines works smoothly through the retort, and gives improved tar and gaseous yields compared with those from the crushed coal. The rate of carbonization is increased by 20 to 25 p.ct. The coke produced is smaller than that from the crushed coal, and high steaming makes it more readily broken during handling.

Regarding the behaviour of the rich swelling coal, this gives trouble with sticking, especially with high top heats, which cause rapid scurfing-up of the retorts. Raising the throughput within limits, improves the working of the coal, but entails excessive steaming to make a gas of a calorific value much below 500 B.Th.U. When in cobble form, the coal works better than when it is crushed, and also gives a lighter and smaller coke, which is more suitable for domestic fires.

Where continuous verticals and horizontals or ovens are already in existence, the author suggests that it is a good plan to screen the coals for the verticals over (say) a 1-in. mesh, and carbonize the smalls together with the highly swelling coals (*e.g.*, those which do not work with full effectiveness on verticals) in horizontals or ovens. If this method is adopted, the verticals can be steamed to give a large thermal yield of lower quality gas, which, when mixed with the rich horizontal gas, will give the desired caloric value. This scheme has proved highly successful at the Nechells Works of the Birmingham Corporation. It is pointed out that it may be necessary to keep the two types of coke separate, and find different markets for them. Where it is necessary to use coals of dissimilar swelling properties on verticals, they should be well blended, and segregation of sizes should be prevented as far as possible.

Mr. Rhead, in concluding his paper, recommends that more scope be given for technical control in the retort house. He is of opinion that it is more than ever true to-day, with our improved, but highly technical, methods of carbonizing, that profits are to a large extent made or lost in the retort house. As with other systems, vertical plants frequently do not receive the technical supervision necessary to get the best results; and this is to be deplored, because they respond remarkably to intelligent treatment, and deteriorate rapidly without it. Some of the methods and instruments mentioned in this paper could be adopted on any works, and would without doubt give valuable information to the engineer. We agree with the author that the expense of making possible the isolation of a portion of the carbonizing plant, so that the gas can be sent through a separate, but relatively small, purifying system, and metered, would be amply repaid by the value of the information yielded.

T. F. E. RHEAD, M.Sc., A.I.C.
Chief Chemist, Birmingham Gas Department.

Alternative Method of Scurfing.

All who heard Mr. Rhead's outline of his paper endorsed the President's remark that the contribution had enriched the records of the Institution. Mr. W. J. Smith, B.Sc., of Bolton, was the first speaker in the discussion, and his remarks were concerned with the production of water gas in continuous verticals in his own town; the idea being to free the retort from scurf in a manner which obviates emptying and burning-off. This latter operation is not good for the retort, and, indeed, besides entailing a loss of about 10 p.ct. in plant capacity, can be a source of serious damage. Mr. Smith explained that it is easily possible to obtain a water gas of about 300 B.Th.U. per c.ft. and having a content of CO_2 not exceeding 5 p.ct. As for the coke, this is suitable for sale or for use in the producers. The scheme is of particular advantage in present circumstances, for with the foreign coal which is

now being carbonized, more frequent scurfing is necessary. Dr. A. Parker mentioned that work similar to that undertaken by Mr. Rhead had been carried out in the Corbet-Woodall experimental plant at Leeds. Conditions at Leeds are, of course, different from those at Birmingham; and the investigation has been concerned with horizontal carbonization at lower temperatures. Even so, Dr. Parker, like Mr. Rhead, found that with the larger grades of coal the coke is more friable than with the smaller grades, that the yield of tar and the rate of gas production are greater. Dr. Parker then pointed out what an important factor internal heating is in carbonization practice in continuous verticals. This, he said, was clearly brought out in the figures for the throughput when using the larger grades of coal, which allow steam and hot gases to circulate through the charge to the best advantage. In ordinary vertical practice, a considerable proportion of the steam admitted to the retort is wasted, due to channelling, and, moreover, in condensing results in a very weak liquor. It seems necessary, continued Dr. Parker, that coal carbonized in verticals should be of a fairly large size; and consequently, if blending were practised, and the coals were finely crushed before blending, it might be advisable to briquette the resulting mixture.

Sticking of Charges.

Dr. E. W. Smith was the next to join in the discussion, and he, too, pointed to the advantages of the new system of scurfing, by which it is possible to maintain the evenness of the heats and prolong the life of the setting. He put forward the view—and all engineers in the industry will share it—that the fundamental in carbonizing practice is low cost per therm. If higher thermal efficiency entails dearer gas, it is only common sense to adopt methods which, though perhaps slightly less efficient thermally, are much more efficient financially. Dr. Smith agrees with the former speaker that sensible heat—which does not operate in static systems of carbonization—is of great importance when verticals are the carbonizing unit. He wondered whether Mr. Rhead had arrived at a conclusive opinion that the swelling property of a coal was the most important factor in producing sticking in the retort. To Dr. Smith's mind, this is very often the result of irregularity of charge, sudden and irregular heating, and even of overpoking. In his reply, however, Mr. Rhead said that semi-fluid coal has an adhesive nature, and this intrinsic property of the plastic mass plays an important part in the sticking of the charge in the retort, even though the latter is a smooth one. Dr. W. B. Davidson also had something to say on this question. He remarked that the plastic properties of certain coals proved highly objectionable in low-temperature carbonization—so much so that a classification of coals according to their degrees of plasticity had had to be undertaken, and those coals exhibiting too pronounced plastic characteristics ruled out. Even smooth steel retorts did not overcome the sticking difficulty. He suggested that a solution might be found in the American "thermodizing" process, in which, prior to carbonization, the coal was heated to a temperature of 300° C., and maintained at this temperature for a considerable period, in a current of air. This rendered the material less plastic, and easier to work. There were many other points of interest in the discussion. Mr. J. W. McLusky, of Glasgow, mentioned another difficulty, with which he has been faced at Provan. The coals used there are selected so that a high throughput can be maintained in the vertical installation. They experience no trouble with sticking, but are apt to get a high percentage of breeze in the coke. However, he is going to remedy this. Dr. Geoffrey Weyman, of Newcastle, said that sight must not be lost of the fact that Mr. Rhead's valuable contribution was applicable to horizontal carbonization practice; and Mr. F. P. Tarratt, of Newcastle, remarked that Durham coking coal can be carbonized easily in vertical retorts provided that proper attention is paid to uniform heating and regular rodding. Space, however, forbids greater detail here. Suffice it to say, therefore, that in Mr. Rhead's paper and in the discussion which followed it there is a veritable mine of information on factors influencing carbonization in verticals and also in horizontals.

Refractory Materials.

According to the gas industry's present specification for refractory materials, the standard test for contraction and expansion is carried out at a temperature of 1410° C.; and as in some cases—particularly in the neighbourhood of the zone of combustion—bricks are regularly exposed to a higher temperature, it has been suggested that, among other clauses, the contraction and expansion test needs revision. Reliable information is being collated by the Refractory Materials Joint Committee, who this year present nine papers in which the results of researches of the British Refractories Research Association are recorded.

Four papers are by Mr. A. J. Dale; and the first of these deals with the premature failure of combustion chamber material. It is suggested that fine-grained, friable material with a silica content in the region of 88 p.ct., and containing considerable free quartz, needs special care during the end of the "slow-fire" period; particularly if the iron and alkali contents of the brick are high, and if the colour suggests a homogeneous distribution of the iron compounds. The investigation indicates that combustion chamber material should have a moderate or high refractoriness, and that there should be good cohesion between grog and matrix up to maximum working temperature.

Mr. Dale's second communication is concerned with the effects of temperature on the mechanical properties of silica products. Thirty-three silica bricks were examined under various load and temperature conditions; and it is stated that any orderly relations between such data as ordinary refractoriness, density, porosity, or even chemical composition, considered separately, and the behaviour of silica bricks under stress at different temperatures are very indistinct, if, indeed, they exist at all. On the other hand, making, mixing, and firing procedures, and particularly the nature of the bond, are undoubtedly factors of first importance. From the users' point of view, it would seem futile to describe a silica brick as good, bad, or indifferent unless the conditions under which it is to be used can be defined.

The third paper set out the results of an investigation into the control of silica-brick making, based on load test indications; and the fourth considers the testing of refractories for resistance to slag corrosion and erosion.

In the fifth paper, by Mr. A. E. J. Vickers, experiments are described relating to the effects which different atmospheres produce when a refractory material containing pure ferric oxide is heated in them. It is explained that nitrogen, oxygen, and air have no detrimental effect, carbon dioxide is comparatively harmless, while carbon monoxide, sulphur dioxide, hydrogen, and water vapour produce a marked drop in the refractoriness of the materials investigated—the influence of water vapour being especially pronounced in this respect. The effects seem proportional to the amount of ferric oxide contained in the refractory.

Then follows a paper, by Mr. A. T. Green, relating to the temperature diffusivities and thermal conductivities of silica refractories at high temperatures. He states that the modern well-fired silica product has a relatively high coefficient of thermal conductivity and temperature diffusivity at the higher temperatures. In fact, the extra heat treatment which this product receives appears to have a determining influence on its conductive properties. Investigation on a material containing a relatively large amount of cristobalite showed that it has an exceptionally good conductivity and a high value for the coefficient of temperature diffusivity at high temperatures. Inefficient heat treatment, it is observed, results in the production of a very poor conducting material, which has a remarkably low value for the coefficient of temperature diffusivity. The rate of increase of the latter property at higher temperatures is pronounced—a fact which points to the influence of pore-spaces in helping the transmission of heat at temperatures *circa* 1100° C.

In the next paper, by Mr. Green, the author compares the temperature diffusivities and thermal conductivities of silica and fireclay refractories. In general, he says, the diffusivities of silica products, both at lower (700° C.) and

higher (1200° C.) temperatures, are higher than those of fireclay products; and silica bricks show a greater rate of increase of diffusivity and thermal conductivity with increase of temperature than do fireclay bricks. The influence of the apparent specific gravity on the coefficient of thermal conductivity of both silica and fireclay materials is discussed in detail; and it is shown that the apparent specific gravity of a well-fired silica brick is considerably less than that of a fireclay brick, and consequently this tends to give lower values for the coefficient of thermal conductivity of silica products. A few further results may be epitomized as follows: Some of the superior well-fired silica bricks are better conductors of heat than the average fireclay product at lower temperatures (800° C.); many silica bricks and ordinary firebricks have approximately equal conductivities at such temperatures; most silica bricks are better conductors than fireclay bricks at higher temperatures (1200° C.); poorly-burned silica goods are comparatively poor conductors. It is pointed out that a material possessing a low porosity is not necessarily a good conductor of heat; in many instances, the reverse holds good.

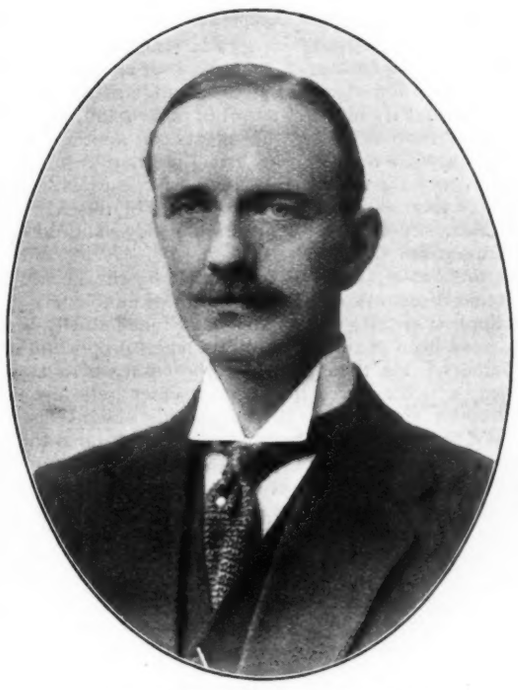
The eighth contribution, also by Mr. Green, shows the effect of usage on the thermal conductivity of a semi-silica material used in a coke-oven wall; and the final paper, by Messrs. A. T. Green and H. Edwards, deals with the spalling of silica refractory material at low temperatures. In this the cristobalite transformation is shown to be particularly effective in causing spalling, while the tridymite change also causes it, though to a less extent. The authors state that there is apparently no connection between the diffusivity and the spalling tendency under the conditions of their experiments. Also the elasticity of the product plays an important part in the spalling of silica products at low temperatures.

A New Specification Needed.

Following the introduction of the Report by Mr. J. P. Leather, the Chairman of the Refractory Materials Joint Committee, Mr. Thomas Glover emphasized the importance of the work undertaken by the Committee. In spite of the fact that manufacturers had produced vertical retorts which would withstand constant use for five years, he said, there was still plenty of room for improvement in refractory materials and for investigation work concerning them; and he suggested that refractories for use in water-gas plants presented a fruitful field for exploration. Mr. G. M. Gill urged that the value of the report could be enhanced by the inclusion of a practical paper such as that recently read by Mr. W. T. Gardner before the Ceramic Society [and published in the "JOURNAL" for Sept. 22, p. 664]—a paper dealing with the very problems with which all gas engineers have to contend. Mr. Gill thinks that there is a strong case for the amendment of the Institution's present specification for refractory materials, which in his opinion—an opinion which doubtless is shared by many others—is in certain respects out of date. For example, as Mr. Gill remarked, the figure for refractoriness of a material for use in a retort setting may be only a snare and a delusion. A highly refractory material is useless unless that material will withstand the loads to which it is subjected in practice. Often the no-load refractory figure is lowered by as much as 300° C. when the material is under load. Therefore an under-load test is not merely desirable, but necessary. Another point is the after-expansion of silica. In the specification, the test is at a temperature of 1410° C. for two hours. In actual practice this temperature is often exceeded. In America, for example, 1450° C. is an average working temperature. Consequently, said Mr. Gill, it does seem absurd to test a silica refractory at a temperature lower than that at which the material is to be used. The same speaker thinks it advisable to sample and test the material at the manufacturers' end—a procedure which would eliminate the delivery of faulty consignments. Much could be done by a better organized system in this respect. Mr. Tarratt asked why the Refractories Joint Committee should go to the expense of publishing nine lengthy papers, if these could be obtained from another source. Most gas engineers, he suggested, have no time to read carefully all the details of prolonged and intricate scientific investigations on refractory materials. They are, of course, intimately concerned with the results of the work, which they are all out to follow carefully. Would it not be better, he urged, if the Committee concentrated on these results, and abandoned the publication of the actual researches. Mr. Leather replied that the only means by which gas engineers could become acquainted with the researches was through the publications of the Joint Committee.

Service to the Consumer.

By this time there can be no doubt about the excellent results which follow careful sowing of maintenance seed. Glasgow provides a worthy example of the truth of this statement; and Mr. J. W. McLusky's paper describing the maintenance scheme in operation in that city was greatly appreciated by those who had the good fortune to be present at the meeting, and will be helpful to any who are contemplating similar activities in connection with their own undertakings. Mr. McLusky's description constituted the first part of a joint paper bearing the title "Service to the Consumer." In working the Glasgow system—which is a "free" one, costing 1d. per



JOHN W. McLUSKY, M.I.Mech.E.
Engineer and Manager, Glasgow Corporation Gas Department.

1000 c.ft of gas made—the area of supply is divided into the wards of the city, and outlying districts are treated separately. In all, there are 37 wards and seven districts. Each ward, having about 10,000 consumers, is divided into four sections. In the domestic wards, one man per section in able to cope with the work; while in the business wards, two men are allocated to each section. Each man is visited by an inspector (who has the supervision of about twenty men) at least every second day. Inspectors have access to all premises visited by the fitters, and make full use of their opportunities to further the sale of gas.

Mr. McLusky gives the costs of the scheme for the ten months ended March 31. During this period, 1,292,347 meters and appliances received attention; and the average cost per appliance, including labour, material, and oncost was 7·39d. The cost per meter connection was 3s. 10·97d.; and the total cost in relation to gas made worked out at 1·11d. per 1000 c.ft., equivalent to 0·236d. per therm. It is significant that the orders for cooking and heating appliances received by the Department during the twelve months ended May this year (when the scheme was complete) exceeded those for the previous twelve

months (when the scheme was incomplete) by 2417, or approximately 45 p.ct.

The author mentions that the system has encountered organized opposition from the Master Plumbers' Association of Glasgow, which opposition still exists, in spite of the facts that the scheme has created a demand for better-quality fittings, and that thousands of orders have been passed to their members for the fixing of new cookers and fires. Apart from this prejudice, however, the scheme has proved popular with every class of consumer, and has resulted in a remarkable reduction of complaints.

Mr. McLusky concludes his paper by a series of specimens of maintenance cards, requisition forms, &c., used at Glasgow. The thought which at once springs to mind in studying this paper is that, for any maintenance system to be successful, the problem must be tackled wholeheartedly and thoroughly. Haphazard action, however well meant, is futile.

The Question of Gas Charges.

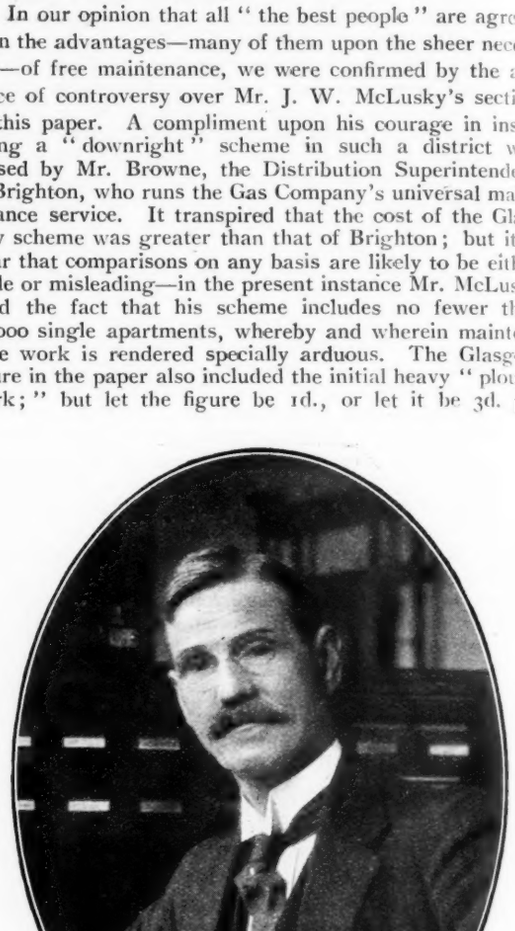
The second part of the joint paper was by Mr. W. B. McLusky, Halifax, who deals with the system of gas charges employed by the Halifax Gas Department. The problem is one of first-rate importance; and the feeling has forced itself upon us that the gas industry should ignore the past, regard the present, and revise the existing system of charging for gas in relation to the present and future possibilities of each class of consumer. There is no need to imitate some of the strange methods adopted by the electricity industry; on the other hand, it is absurd to waste time decrying the efforts of another industry which have in many cases brought good results. Requirements have to be met as they arise, and with as little waste of time as possible. Knowledge of this has guided Mr. McLusky in his constructive policy, and his paper is stimulating.

At the outset, he "takes the bull by the horns," and says that discounts and differential rates as they are generally applied in the gas industry have failed chiefly because they have been available to only a small proportion of the consumers. He then points to the equity of a two-part system, which ensures that no consumer gets any rebate or discount until he has discharged his obligations in respect of fixed charges. In every case, he obtains the commodity at an appropriate price, and at his own expense—not at the expense of his neighbour. The author emphasizes the fact that the cost of gas production—however low it may be—is of less value to the consumer than is a large consumption per service-pipe. Under the Halifax bi-part tariff, the smallest householder pays a fixed charge of 39s., and the smallest industrial user £2, per annum. The price paid for the gas is then based on a sliding-scale depending on consumption. The author suggests that the Perth Parcels Scale, by which the price is regulated solely by consumption, and under which there is no fixed charge, does not go far enough. The intermittent user with a large hourly demand involving much capital expenditure pays no more in a quarter for the volume of gas consumed than does a consumer who, with a small but regular long-period demand, uses as much gas with a far less expensive installation. This defect is removed in the Halifax scale of charges.

As is well known, Mr. McLusky has brought into practice what is known as the "standard requirement" scheme. The standard requirement for the domestic consumer is 37½ c.ft. per annum per sq. ft. of floor area; and any gas consumed above this amount is charged at non-lighting rates. This is an optional system. In many cases, it pays a consumer to adopt it; in some instances, as the author points out, the consumer benefits more by buying his gas at a flat rate. To the suggestion that equally large quantities of gas would be consumed in Halifax if ordinary flat rates were charged, the author has the irrefutable answer that experience proves the contrary. In his opinion, the existing system of levying charges for gas adopted by the gas industry is inequitable, and stands between the industry and a large increase in business. Many far-seeing gas administrators will share this view. There is, however, little doubt that the whole gas industry is waiting for a lead in this connection. Mr. McLusky concludes his paper by giving particulars of the scale of charges adopted at Baltimore and Chicago.

The Discussion: Ayes—

In our opinion that all "the best people" are agreed upon the advantages—many of them upon the sheer necessity—of free maintenance, we were confirmed by the absence of controversy over Mr. J. W. McLusky's section of this paper. A compliment upon his courage in instituting a "downright" scheme in such a district was passed by Mr. Browne, the Distribution Superintendent of Brighton, who runs the Gas Company's universal maintenance service. It transpired that the cost of the Glasgow scheme was greater than that of Brighton; but it is clear that comparisons on any basis are likely to be either futile or misleading—in the present instance Mr. McLusky cited the fact that his scheme includes no fewer than 40,000 single apartments, whereby and wherein maintenance work is rendered specially arduous. The Glasgow figure in the paper also included the initial heavy "plough work;" but let the figure be 1d., or let it be 3d. per



W. B. McLUSKY.

1000 c.ft., Mr. McLusky says free maintenance should rule supreme.

And Noes.

As for the charges section of the contribution, here we had a mild foretaste of many wordy battles which will undoubtedly be joined before the gas industry in this country gives way before the differential charge. Mr. Browne remained in the lists; and "quip modest" was met with "retort courteous." Mr. Evetts sought to confound with cold logic the floor area basis. A scientific basis was not easy to find, but the fact that a basis was unscientific did not prevent people taking advantage of it; and a floor-area basis was unscientific. A consumer's service pipe, meter, and appliances should suggest his standard requirement. It was wrong to leave a scale optional—it did not force out the unremunerative parasite. Chapter and verse were given for apparent anomalies in the paper; and all of these were ascribed to the unscientific basis of the Halifax scale. Photographs have been said to be above mendacity; but two, accompanied by figures, were shown up by Mr. Evetts in rather a bad light.

Followed a breezy exposition of the Toronto tariff, by Mr. Hewitt, General Manager of the Consumers' Gas Company, who has at his finger tips the intricacies of practice across the water; and sound advice went with his explanation. We shall be forced to change our ways; other-

wise the fate of losing our good customers stares us in the face, and the poor will be always with us. We should bear in mind, however, that a change of tariff was most agreeable when it coincided with a decrease in the price of gas.

Mr. Thomas Glover paid tribute to the ingenuity of the Halifax scheme; and the President gave a fair indication of his viewpoint by directly coupling the policy of differential charges with maintaining the goodwill of the consumers. Mr. Botley also appealed for any written communications from members which might assist the task of the Committee of Investigation over which he presides.

Mr. W. B. McLusky was minded to sweep widely in replying to the discussion. For long years the gas industry had accepted the basis of floor area in making lighting calculations; and the theoretical lighting load for a house was really the basis of his scheme. His tariff had the virtue of permitting infinite variation between consumers; but such would not be the case if one started calculating from the bore of the service pipe. In any case, he is satisfied that the Halifax scheme is "generally accepted," and that it has been responsible for a substantial increase in consumption.

Gasification of Special Cokes in Steam.

The Fellowship Report of 1924, by Dr. S. Pexton and Prof. Cobb, showed what an important factor is the physical structure of the coke on the gasification of coke in steam. It demonstrates that, when 900° C. coke, bye-product coke, and 1270° C. coke are gasified at the same temperature, under the same conditions, and with identical rates of steam supply, there is a wide variation in the CO : CO_2 rates in the three cases. The dry water gas produced from the 900° C. coke contained 48·4 p.ct. of carbon monoxide and 1·1 p.ct. of carbon dioxide; the gas from the bye-product coke had a composition of 41 p.ct. of carbon monoxide and 6·4 p.ct. of carbon dioxide; while the amount of carbon monoxide in the gas produced from the 1270° C. coke was only 34·4 p.ct., and the figure for carbon dioxide 10·8 p.ct.

The Fellowship Report of 1925, by Mr. C. B. Marson and Prof. Cobb, described what effect the addition of 5 p.ct. of each of a number of common inorganic compounds to an almost ashless Yorkshire coal prior to its carbonization at 500° and 800° C. has upon the chemical and physical properties of the cokes produced.

In the 1926 report, the results are given of the behaviour of these special cokes (made by the addition of 5 p.ct. of such oxides as silica, alumina, lime, and ferric oxide, and of equivalent quantities of calcium carbonate and sodium carbonate, to the original coal) during their gasification, with particular reference to their gasification in steam. The results of the investigation show that silica and alumina are of little importance, but that lime, ferric oxide, and sodium carbonate in increasing degree have a remarkable influence, giving a much higher steam decomposition with a lower carbon dioxide content in the gas for the same rate of steam supply. The percentages of steam decomposition were 61 for "pure" coke, and 82, 91, and 98 for the calcium oxide, iron oxide, and sodium carbonate cokes respectively; while the corresponding percentages of carbon dioxide in the water gas made were 9·2, 5·4, 2·6, and 0·4. The extreme case was that of sodium carbonate coke. It is pointed out that the difference in the behaviour of the cokes may be due to catalytic activities of the added constituents, or may be explained by the previous action during carbonization of these constituents in modifying the physical properties of the coke. Work is in progress to determine this. Mr. W. R. Branson made experiments which demonstrated that cokes known to be highly reactive with steam are also more reactive with carbon dioxide and air. He found that the percentages of carbon monoxide, after passing carbon dioxide at the same rates through different cokes, were 6·6, 29·9, 45·6, and 89·0 for the "pure" coke, iron oxide coke, calcium oxide coke, and sodium carbonate coke respectively.

As the result of experiments carried out in France, J. P. Arend and J. Wagner concluded that the reactivity of cokes increases with their porosity, and that the latter property, being dependent on the evolution of volatile matter when the coal, having softened by heat, begins to harden again, can be artificially increased by the addition of compounds which evolve gas at the correct temperature to have an effect on the plastic mass. In this respect they found that ammonium carbonate, which decomposes at low temperatures, does not produce any change. These investigators also demonstrated that pure ferric oxide gave a marked effect. During the coking, the reduction of the iron oxide causes an evolution of gas at temperatures from 600° to 700° C.; and this produces a considerable increase in the porosity and reactivity of the coke. They came to the conclusion, too, that the reduced iron acts as a catalyst during the combustion of the coke by carbon dioxide.

From the foregoing, it would appear that the greatest effect of adding inorganic compounds to coal before carbonization is to increase the porosity of the coke, and that the increase in this physical characteristic is far more important in its effect on the reactivity of the coke than is any catalytic effect. This controversial point, however, is being cleared up by the workers at Leeds University. In the blast furnace the chief requirement as regards the manner of burning of the coke is that the rate should be an economical one. Whereas a dense coke is usually found to burn too slowly, a highly porous coke burns too quickly. And in this connection R. A. Sherman and S. P. Kinney say that porosity is far less important than the size of the coke. The remarks of these investigators refer to blast-furnace practice, but they may have considerable bearing on the domestic coke problem. This question of size is a very important one. In 1924 Mr. Madden, of Cardiff, asked what size of coke was most suitable for a water-gas plant. The gas industry still awaits an answer to this question.

Before terminating this brief note, it must be said that this year's Fellowship Report is extremely valuable, and that the observations contained therein will doubtless have numerous industrial applications in connection with water gas manufacture, blast-furnace work, the generation of hydrogen, and generally with the combustion of solid fuels in air or oxygen.

Discussion.

The potential value of the report was stressed in the discussion, wherein several speakers hinted at practical developments from the detailed research. The President is enthusiastic about the work, and considers that some of the members of the Institution might themselves follow up lines of experiment indicated. He himself intends to pursue the investigation of iron-oxided coke. At the same time, however, he drew particular attention to the fact that the report is only an interim one, a record of work done; that there are as yet no guiding recommendations; and that there is a certain risk in individual experimenting—either of a damaged plant, or of a damped enthusiasm through disappointing results. Dr. Parker pointed out that, in dealing with these special cokes, it is necessary to revise ideas of coke structure being a criterion of reactivity. It is generally accepted, for example, that a coke with small pores and thin cell-walls is better for domestic purposes than one with large cells and thick walls. Yet two cokes with entirely different structure can be made by impregnation to give identical reactivity tests. Those who are thinking of carrying on research for themselves should bear in mind that one great difficulty is to get a representative sample of coke—the ash content of the sample compared with that of the bulk might be responsible for awkward discrepancies.

The relation of research to everyday life was brought out when Dr. Parker recalled the old-fashioned "stunt" of adding washing soda to coke, and the patented preparations which (hypothetically) "made one ton of coal go as far as two." Is the magic now to be elucidated? Mr. Madden told of his apprehension of quenching coke with water from a brackish well his Company had sunk; and of their satisfaction at finding that the coke so quenched showed better ignitibility and freer burning. Asked whether it was intended to carry the research to the more practical stage of burning these special cokes in oxygen, Dr. Marson replied in the affirmative, but said that the normal sequence of experiment is being observed. They

have, however, put out a feeler by burning sodium carbonate impregnated coke in an open fire; and the result had surprised them—an excessive heat, and CO flames right up the chimney. He also said that quenching experiments will be undertaken in due course.

High-Pressure Gas Transmission.

In view of the Government electricity scheme, whereby current generated at a few large stations is to be transmitted at high voltage to sub-stations which will transform and distribute it, the paper on the distribution of gas at high pressure, read by Mr. Arthur W. Sumner, of the Grays and Tilbury Gas Company, is of current interest. The contribution does not aim at showing how gas manufactured at a few central works can be transmitted to towns and villages wherever situated in the country, as was suggested in an excellent article from the pen of Mr. Harald Nielsen, which was published in the "JOURNAL" for Feb. 10; it is not so ambitious as that. But it does demonstrate that a comparatively small undertaking supplying gas at low pressure in an area of 32 sq. miles can, by high-pressure transmission, satisfy the demands of outlying villages scattered throughout an area of 130 sq. miles. If, as is proved in the paper, a small concern can do this satisfactorily, and if a larger undertaking—that of the Harrogate Gas Company—can employ high-pressure gas with great advantage, there is no reason to suppose that the obstacles facing its wider adoption, even to the extent dreamed of by Mr. Nielsen, should such a scheme become desirable, will prove insuperable. However that may be, there is much of present interest in Mr. Sumner's contribution to the Institution's proceedings.

As will be noted from the paper, the Grays and Tilbury Company decided to convey the high-pressure gas in mild-steel pipes; and proper attention was paid to their protection from corrosion. They were wrapped and coated; and the joints, which were oxy-acetylene welded, were protected by painting with dehydrated tar, and by jute wrapping dipped in hot dehydrated tar and pitch. The author rightly lays stress on the need for this protection, upon which he regards the life of the pipes is largely dependent. It is interesting that up to the present no case of fracture of the pipes has occurred. When the work was carried out in 1914, the length of mains totalled 45 miles, and the cost, including compressors, governors, and receivers, amounted to £24,645. Since then extensions have been made, and the length of mains is now 60 miles; and they cover 22 parishes out of the 41 in the high-pressure area. The consumers on this system number 4965; and the quantity of gas delivered is 48 p.ct. of the total sales.

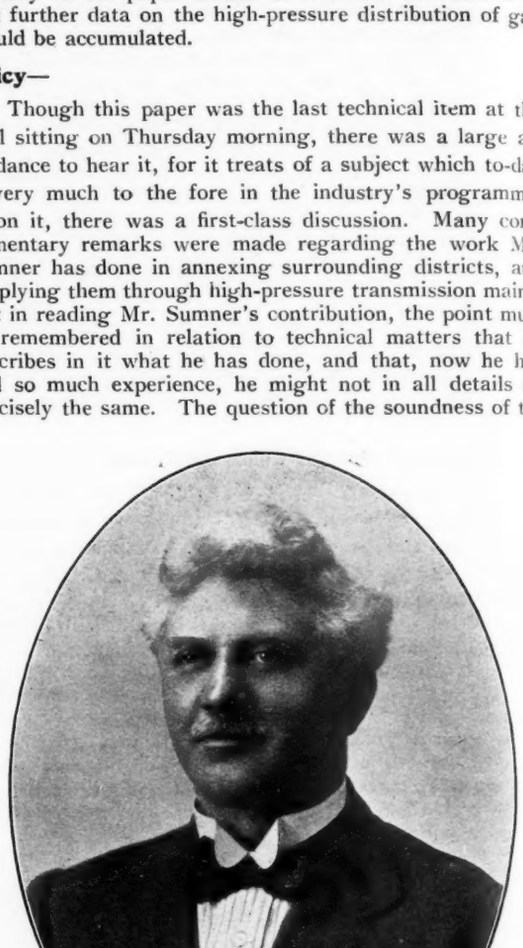
A high-pressure system is certainly flexible. For example, the author mentions that at a village approximately twenty miles away from the works, a 1-in. service pipe, 70 ft. in length, successfully supplies gas to an 87-H.P. engine. Allusion is also made to a village ten miles distant from the works, where a 1-in. pipe 1¼ miles long supplies no fewer than 31 consumers.

Of course, the most important question of all is that of cost. Mr. Sumner had no direct data for determining accurately the cost of compression; but he estimates this at 1·7d. per 1000 c.ft., which, with gas at 460 B.Th.U., works out at 0·37d. per therm. This figure bears out Mr. Nielsen's statement that, to transmit gas of low calorific value, though the therm is initially produced at a lower cost, will not effect economies at the consumer's end. The 1·7d. per 1000 c.ft. does not include the cost of upkeep of the compressors, which in 1925 figured at 0·128d. per 1000 c.ft., and would make the total cost 1·828d. per 1000 c.ft. Towards the end of his paper, Mr. Sumner gives a comparison of the costs of cast-iron mains for low pressure, and butt-welded, wrapped, and coated steel pipes for high pressure, together with their costs of laying and their capacity. The comparison between a 6-in. cast-iron and a steel main of the same size is of interest. The total cost per yard for the former is 9s. 11d.; and the capacity, at a pressure of 6-in. inlet and 5-in. outlet, 9088 c.ft. per mile. For the 6-in. steel main, the cost is 12s. 3d. per yard, and the delivery capacity, at 20 lbs. inlet and 15 lbs. outlet pressure, 73,000 c.ft. In both cases the costs include labour and material. The ratio of the cost of cast-iron to steel main is 1 : 1·23 per mile, and the delivery ratio is 1 : 8. As for services, low-pressure pipes show a decided economy.

Study of the paper makes us feel how desirable it is that further data on the high-pressure distribution of gas should be accumulated.

Policy—

Though this paper was the last technical item at the final sitting on Thursday morning, there was a large attendance to hear it, for it treats of a subject which to-day is very much to the fore in the industry's programme. Upon it, there was a first-class discussion. Many complimentary remarks were made regarding the work Mr. Sumner has done in annexing surrounding districts, and supplying them through high-pressure transmission mains. But in reading Mr. Sumner's contribution, the point must be remembered in relation to technical matters that he describes in it what he has done, and that, now he has had so much experience, he might not in all details do precisely the same. The question of the soundness of the



A. W. SUMNER, A.M.I.Mech.E.
Engineer and Manager, Grays and Tilbury Gas Company.

policy of getting out into surrounding areas from well-conditioned works was admirably and philosophically dealt with by Mr. Walter Hole. A great change is coming over the country. There is the migration of population from large centres to country places for residential purposes; and there is the greater mobility which mechanical road vehicles give in enabling this to be done. Such changes, with others, must have an influence upon gas trading, as they do on business in other directions. Mr. Hole wisely advises that we should look at the question not from the point of view of what the position is to-day, but what it will be in a few years' time. There should be no difficulty in this if we give scope to an active imagination. Mark this: The true policy is to be first in possession.

And Practices.

Mr. Hole also asked several questions—among them whether Mr. Sumner finds any oscillation back into his gasholders which in any way affects the low-pressure system. Mr. Sumner's reply was in the negative. Another point which was raised by the same speaker was as to the relative merits of butt-welded joints and socket-welded joints. Most of the speakers who have had experience were favourable to the former. But as Mr. B. R. Parkin-

son said, much depends upon the skill of the welder. If he has not the necessary skill, then the sleeve joint is preferable. The reply to that is that the first thing an engineer should see to is that the welder is a man of skill. Then all should be well with the butt-welded joint. Compression costs came in for some examination; but the paper must be referred to for details regarding the point. Alluding to it, Mr. Parkinson states that he has come to the conclusion that 2 miles is the minimum for a decision between high pressure and low pressure. If one has only 2 miles or less of mains without any service on it, then it has to be considered whether the cost of compressors should be incurred. Corrosion formed another peg on which many remarks were made. Mr. H. D. Madden referred to a case of high-pressure mains at Cardiff which were laid some fifteen or sixteen years ago. A section has been opened up; and the wrapping and pipes were found to be as good as new. But there was internal corrosion, which, from what he said, appears to have been largely cured by the use of petroleum vapour, inasmuch as the corrosion now found in the governors is practically negligible.

The old question of whether steel or cast-iron pipes should be used popped up here and there in the discussion. Mr. G. M. Gill tells us that in the United States cast-iron mains, with ordinary sockets, are freely adopted for much higher pressures than we are accustomed to in this country. In fact, it has become general practice to distribute gas up to 10 lbs. per square inch. One engineer in America uses cast-iron mains with pressures up to 25 lbs. per square inch; and the joints are composed of cement and lead, and have proved very satisfactory. This reminds us that there were references to experiences with lead-wool joints and rubber joints, and, in both instances, of a very favourable nature. Regarding the effect of compression on calorific value, this also was acknowledged to be of an infinitesimal order.

There were several references to the use of cylinders with high-pressure transmission systems; and in this connection Mr. Gill recalled the American use of spherical gasholders, constructed of steel, which are equal to a pressure of 50 lbs. per square inch. Up to half-a-million c.ft., they compare favourably with ordinary gasholders. It was considered by the President that high-pressure distribution is going to bring about the use of more district holders—high-pressure being used for transmission of gas to holders, from which it would be distributed at the requisite district pressure. Mr. Sumner has had no experience of storage cylinders; and he prefers to adhere to the use of gasholders. He made a point in this connection when he said it seems to be wrong to make your high-pressure plant do all the work at one period, and have little or nothing to do at other periods. With gasholders, it is possible to put through three times the quantity of gas; and it seems to him to be the right course.

It will be found from the complete report that the discussion, like the paper, was excellent, and highly instructive.

The Final Business.

We came to the final stage of this most interesting and valuable meeting. There was great enthusiasm when it was learned that Mr. John Wilkinson, of Nottingham, succeeds to the Presidential Chair, and that Mr. J. W. McLusky, of Glasgow, is to be the Junior Vice-President —Mr. H. D. Madden now becoming the Senior Vice-President. The announcement that Mr. W. E. Price will continue to tenant the office of Hon. Secretary was also received with applause. Very gracefully Mr. Wilkinson acknowledged his election; and, at the same time, he handed the President's certificate to the retiring occupant of the chair. In eloquent terms, he spoke of the great value of the work Mr. Botley has done during his term of office for the industry and the Institution. Many of us know that all he said is richly deserved. The acknowledgment by Mr. Botley was in terms in which depth of feeling and much gratitude intermingled. Then there were the votes of thanks to the Council, the Hon. Secretary, authors of papers, scrutineers, and others—including the friend of all, Mr. W. T. Dunn. By all in office, the Institution has been well served during the period since the last meeting—a period marked by much trouble. Those who will carry on affairs during the coming year will, we know, maintain the same high standard of effort in well-doing in the interests of the Institution and the industry generally.

JOHN WILKINSON, O.B.E.
Senior Vice-President.

SOCIAL EVENTS.

THE PRESIDENT'S RECEPTION.

The exigencies of the moment were solely responsible for the fact that fewer invitations were accepted for the President's reception on the Tuesday evening. As it was, no fewer than 450 guests enjoyed the hospitality and entertainment provided for them at the Connaught Rooms, Great Queen Street.

Accompanying the President, as he received the guests in the banqueting hall, were his daughter, Miss Botley, and his sister-in-law, Miss Reeves. The ladies carried charming bouquets—Miss Botley's having been presented, on behalf of the Southern Association of Gas Engineers and Managers, by the Secretary, Mr. H. C. Smith; Miss Reeves' being from the Institution of Gas Engineers, on whose behalf it was presented by Mr. John W. McLusky. During the reception, appropriate music was rendered by "Peacock's Musiquers," whose unflagging enthusiasm throughout the evening earned the praise of all. At 9 p.m. dancing commenced, and continued till midnight, when a delightful party broke up unwillingly, albeit with an eye on the busy morrow.

From the company it would be difficult to select only a few names for mention, so it must suffice to say that all the industry's organizations were officially represented. Beyond that, we would record that Mr. W. J. A. Butterfield represented the Gas Referees, and Prof. John W. Cobb, C.B.E., the University of Leeds; and that many had the pleasure of renewing their acquaintance with Mr. H. V. Mitchell, of Brighton (Victoria), and Mr. Arthur Hewitt, of the Consumers' Gas Company of Toronto, the latter being accompanied by his son.

To omit mention of the Stewards, we should regard as a grave dereliction of our duty. From north, east, south, or west, they all performed yeoman service in assisting the President to provide an evening of most pleasant relaxation.

THE LUNCHEON.

Offered by the President and Council.

On Tuesday, the President and Council gave a luncheon at the Savoy Hotel; a number of distinguished guests being present, together with representatives of the Press.

Accompanying the President at the top table were Sir Charles Morgan (Past-President of the Institution of Civil Engineers), Sir Frederick L. Nathan (President of the Institution of Chemical Engineers), Mr. W. J. Glenister (Chairman of the Hastings and St. Leonards Gas Company), Mr. P. W. L. Ashley (Principal Assistant Secretary, Industries and Manufactures Department, Board of Trade), Mr. C. Pratt Sparks (Past-President of the Institution of Electrical Engineers), Mr. J. F. Ronca (Director of Gas Administration, Board of Trade), Mr. H. C. Honey (late Director of Gas Administration), Dr. C. H. Lander (Director of Fuel Research), Dr. T. Lewis Bailey, Mr. J. E. Cowen (President of the British Commercial Gas Association), Mr. F. J. Gould (Chairman of Council of the Society of British Gas Industries), the Rev. H. C. B. Foyster, and Alderman F. J. West (Ex-Lord Mayor of Manchester).

The toast of "The King" having duly been honoured,

The PRESIDENT read a telegram from the Lord Mayor of Norwich expressing regret at his inability to be present, and good wishes to the Institution and those present at the luncheon.

FRIENDSHIP WITH THE ELECTRICAL INDUSTRY.

Sir CHARLES MORGAN (Past President of the Institution of Civil Engineers), proposing "The Institution of Gas Engineers," said he was very pleased to be present with his old friend Mr. Botley, whom he had had the honour of knowing for a good many years—and also his father before him. Having regard to the character of Mr. Botley's father, he was certain that the Institution had a President who was worthy of it. The work done by the Institution for the gas industry was very important—not that it was necessary to have a body of eminent gas engineers and managers to look after the units of the industry, but the industry did want men of wide experience who could make friends with their opponents in the electrical industry, and so forth, so that they could as far as possible merge the two interests where they existed in one district. Provided they had men on both sides with sufficiently wide views, then, at all events in his experience, the industries got on very well together. The gas industry could supply light in the smaller class of property; and it could also supply something beyond what the electrical industry could do—namely, heat. He believed that gas for heating was far cheaper than electricity. Indeed, this was admitted by both sides in the controversy. He had had the honour of listening two years ago to the Presidential Address of the President of the Institution of Electrical Engineers; and he commended it to all, for a more fair-minded exposition of the relative merits of gas and electricity it had not been his experience to hear on any previous or subsequent occasion. It was stated there very plainly and very fairly that in some places there was nothing equivalent to gas, while in other places there was a field, and a proper field, for electricity. That being so, if it were only possible to come to some reasonable solution of the merits and demerits of both systems, then in most cases gas and electricity supply ought to be in the same hands. There were loads for electricity, and there were economical loads for gas; and if they could only get a combination of the two interests in the large and important areas, then it would be to the great advantage of the public as well as of those who had their money in these industries. Perhaps he had better not go any farther into the matter, because there were so many present who could speak much better than he as to the advantages or disadvantages of the two industries. He would therefore leave the subject, simply saying that he was very delighted to be present and to propose the toast of the Institution of Gas Engineers.

LOYAL GAS STAFFS.

While he did not know a great deal about the Institution, he had the honour to be a Director of one or two gas companies, and could say that he had never met—save in his own profession [laughter]—more efficient or loyal officers than he had met in the gas industry; and he was certain that if all pulled together in the general interests, then the gas industry and the Institution would inevitably meet with unbounded success. He therefore proposed "Success and prosperity to the Institution of Gas Engineers, coupled with the name of the President."

Mr. BOTLEY, replying, thanked Sir Charles Morgan for the manner in which he had proposed the toast. He felt he could claim, especially at a time like this, that the Institution through its members was worthy of the things Sir Charles had said of it. There was really, although he had disclaimed it, nobody more able than Sir Charles Morgan to speak of the Institution. Sir Charles was a distinguished railway engineer; and it had been his own privilege to have to submit work to him many years ago. Sir Charles was also a Past President of the Institution of Civil Engineers, and knew, by his contact with reconstruction and new works, what gas engineers were capable of. Therefore, as an Institution, they were grateful to Sir Charles for what he had said; and he (Mr. Botley), knowing the members of the Institution as he did, could assure him that nothing would ever be lacking on their part to merit the commendation for good service to the public which they had received.

CO-OPERATION AMONG ENGINEERS.

Mr. H. D. MADDEN (Vice-President of the Institution of Gas Engineers), proposing "Kindred Associations," said he was handicapped in that he had been asked at very short notice to deputise for Dr. Charles Carpenter. It was a difficult toast to deal with efficiently, because as gas engineers they owed so much to the kindred associations. There was, for instance, the assistance they had always received from the Institution of Civil Engineers, the "parent" Association; and it was the desire of the Institution of Gas Engineers that as many as possible of its members should seek election to the Institution of Civil Engineers, in whose Charter gas occupied a prominent place, and rightly so. Then there was the Institution of Mechanical Engineers, and gas-works to-day were largely dependent upon the mechanical engineer. Coming to the Institution of Electrical Engineers, he said there had been a good deal of antagonism between gas and electrical engineers in the past; but this had now been largely dispelled by, among other things, the Electricity Bill which was before Parliament. In South Wales, civil, mechanical, electrical, and gas engineers all met under one roof and attended not only each others' meetings but also the social functions; they were all one in South Wales, and he hoped that this spirit would prevail throughout the country. Again, reference must be made to chemistry in relation to the gas industry, and to the way in which the Society of Chemical Industry and the new Institution of Chemical Engineers were giving their assistance. Furthermore, in giving such a toast as that of the "Kindred Associations," he felt it necessary to refer to the fact that the Education Scheme of the Institution of Gas Engineers recognized Diplomas given by other institutions; and the latter, in turn, were recognizing the Diploma of the Institution of Gas Engineers. He hoped this spirit of co-operation would continue.

CURB THE "HOT SPIRITS."

Mr. C. P. SPARKS (Past President of the Institution of Electrical Engineers) replied to the toast, and after referring to the encouragement and help always given to the Institution of Electrical Engineers by the Institution of Civil Engineers, mentioned co-operation between gas and electrical engineers. Starting some 40 years ago, there had been great enmity between

the two industries. The gas people were jealous of the new intruder; and, on the other hand, the electrical people were afraid of the gas people. What was the best way to alleviate this? The first thing was to recognize that both industries were in the position of servants of the public; the next thing was to get to know one another better. He had been engaged in the electrical industry for many years; and though he could claim to know a few people in the gas industry, he did not know enough. The Institution of Electrical Engineers talked the matter over seriously last year, and determined to approach the gas industry and see if some "clearing house" could not be set up. He was happy to say that the suggestion was received in very good spirit by the gas industry, and the result was the appointment of a Joint Committee of gas and electrical people. The President of the Institution of Gas Engineers was one of the members of that Committee, and Mr. Milne Watson was another representative of the gas industry. It seemed to him that though this Committee was only a small nucleus of ten—five members from each industry—it was possible for it to set wheels in motion which would bring the two industries more closely together. When this sort of thing happened, it was often thought that the public was going to be "done down," but it was not so. As a matter of fact, it was only men in an industry who knew the channels by which improvement could be made; and if they sat down as business men and experts, they should be able to find some method of co-operation that would spell greater efficiency and greater cheapness to the public. He appreciated what Sir Charles Morgan had said, but would not touch on any controversial point between the gas and electricity industries. His personal view, however, was that there was a field for both, and that it was necessary to curb those very hot spirits on each side who said either that everything must be done by gas or that everything must be done by electricity. Personally, he took the middle course, and believed there was room for both.

Sir FREDERICK NATHAN (President of the Institution of Chemical Engineers) also replied. Though the Institution of Chemical Engineers was one of the youngest of the Technical Institutions of the country, he had every reason to hope that it would make its mark in the world of science and its application in industry, and that in due couse the Institution of Gas Engineers would recognize the value of the Institution of Chemical Engineers in the assistance it would be able to afford the gas industry. After all, the gas industry was very largely a chemical engineering industry; indeed, it was perhaps one of the biggest chemical engineering industries in the country. Therefore, it must in the future be in need of a plentiful supply of chemical engineers; and it was the aim and object of the Institution of Chemical Engineers to provide thoroughly trained men who would be able to take their place in the gas or any cognate industry. The gas industry he regarded as pre-eminently one which had made a great application of science to its work, and everyone realized what a thoroughly efficient industry it was, and what an enormous amount of care and thought had been given to its furtherance in all directions. He hoped that the chemical engineer would assist in increasing the efficiency of the gas industry, and also that the assistance of the Institution of Chemical Engineers would always be available to help the gas industry in every possible way.

Mr. JOHN WILKINSON (President-Elect of the Institution) proposed "The Visitors," and coupled with the toast the names of Mr. P. W. L. Ashley, of the Board of Trade, and Councillor Dymond, Deputy Mayor of Hastings. The President's luncheon, he said, appeared to be growing in size and importance each year, and it was fitting that this should be so. To-day they had many distinguished visitors; and it was fitting that they should, on occasion, have such functions as these in order to hear the views of men engaged in other spheres of public life. The opinions of such men were welcomed, whether they were favourable or otherwise, because it was realized that from true criticism they would always learn something. He offered the visitors a hearty welcome.

BOARD OF TRADE COMMENDATION.

Mr. P. W. L. ASHLEY, C.B. (Principal Assistant Secretary of the Industries and Manufactures Department of the Board of Trade), congratulated the Institution upon its courage in holding its meeting at a time when the burdens falling upon its members were so exceptionally heavy. That, however, was only an example of the way in which, during the past few months of great difficulty, the gas industry had carried on with such remarkable success the maintenance of a great public service; and he ventured to take this opportunity of congratulating the Institution, and through it the gas industry, on its achievement during the past five months. The only other thing he desired to say was that he noticed that not only had the late Director of Gas Administration—Mr. Honey—been included in the list of guests, but also the present Director, Mr. Ronca. He was sure that this was not a case of "making friends with the policeman," but that it was an indication that the relations between the gas industry and the Department which he had the honour to represent had been on the whole remarkably harmonious. At the same time, he assured them that the Department was not likely to fail in its appreciation of the importance of the gas industry, not merely as providing a great national service, but as being part of a great chemical industry on which the well-being and industrial prosperity of the country so largely depended.

Councillor DYMOND (Deputy Mayor of Hastings) said there were one or two reasons why he was particularly glad of the opportunity of responding to the toast. The first was that as a chemist he felt a very keen interest in the chemical processes of the gas industry, and was able to comprehend to some extent the enormous problems involved and to appreciate the services which the industry rendered not only to those whose money was invested in it, but also to the community at large. His second reason was that he came from Hastings to represent the Mayor of that town, whose municipal duties made it impossible for him to come to London to express to the members of the Institution of Gas Engineers the esteem in which their President was held in Hastings. Not only did they in Hastings have a plentiful supply of gas, even during the recent weeks of stress and anxiety, but there existed the most harmonious relations between the Corporation and the Gas Company; and this was largely due to the personality of Mr. Botley. That was something to be proud of when it was remembered that in Hastings the Corporation owned the electricity undertaking. Moreover, the fact that these relations were so harmonious suggested to him that the Company were extraordinarily well managed. Mr. Botley had won esteem in the borough, and he took part in most useful work. Education was down on the agenda for the Institution meeting; and they would be interested to hear that in Hastings Mr. Botley had given valuable assistance in the educational work of the borough. Mr. Botley might think that this work was small; but he could assure him that the Education Committee appreciated his kindness and help. He mentioned this because he believed that what Mr. Botley was doing in Hastings was also being done by other gas engineers in their respective towns. For these reasons he responded for the visitors with great heartiness, and acknowledged the manner in which they had been entertained.

"THE PRESIDENT."

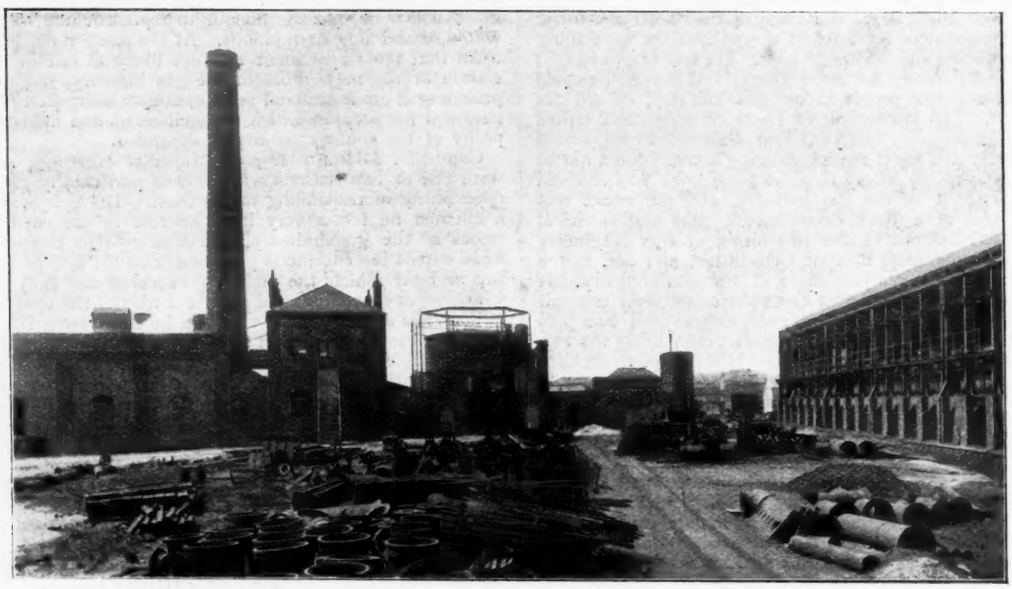
Mr. J. W. MCLUSKY, proposing "The President," said, as a member of the Council who had worked with the President during the past year, that Mr. Botley had impressed him more and more as the year went on with his thoroughness and gentlemanliness in conducting the meetings. Council meetings certainly did help to find out the real men in the industry; and as a Councillor he testified that there were few who had done more than Mr. Botley had for the good of the Institution and the industry. At the same time he wished to express to Mr. Botley the appreciation of the Council of the manner in which he had conducted the business during what the Council as a whole knew had been a very difficult year. For these reasons he asked that a very hearty vote of thanks should be given to the President.

The toast was honoured with acclamation.

KEEP THE FLAG FLYING.

The PRESIDENT replied that it was very gratifying for those who had been working for the Institution to find that their work was appreciated, and he hoped that such good feeling would always manifest itself in the industry; for himself it had been a wonderful year of office. He prayed that the outcome of the unfortunate coal stoppage would be a settlement for the benefit of the dear old country. He had already, that morning, asked them not to relax their efforts; and he begged them again, if it were necessary, to keep the flag flying and see this business through. Mr. McLusky had been good enough to speak of the way in which the Council meetings had been carried through; but that was largely due to the system by which the members of the Council were elected, because it resulted in the best brains in the industry for the time being getting there. He hoped he would not be misunderstood in saying that. Personally, he would soon be on the shelf, but somebody else would come along. There were those in the industry to-day of whom he, as a colleague, could not speak too highly; and as long as the Institution had such people to call upon, it would continue to deserve what had been said of it. By applying research and by co-operation the industry would be able to forge ahead to even greater things than it had already attained. He was deeply grateful for what had been said, and for the honour and privilege of having so many with him at this luncheon.

THE PRESIDENT'S GLYNE GAP WORKS, HASTINGS.



NO. 1 YARD, LOOKING WEST.

To the right is the purifier house; in the centre, the mechanical purification apparatus with the C.W.G. relief holders at the back; and to the left, the power house buildings with the main chimney.

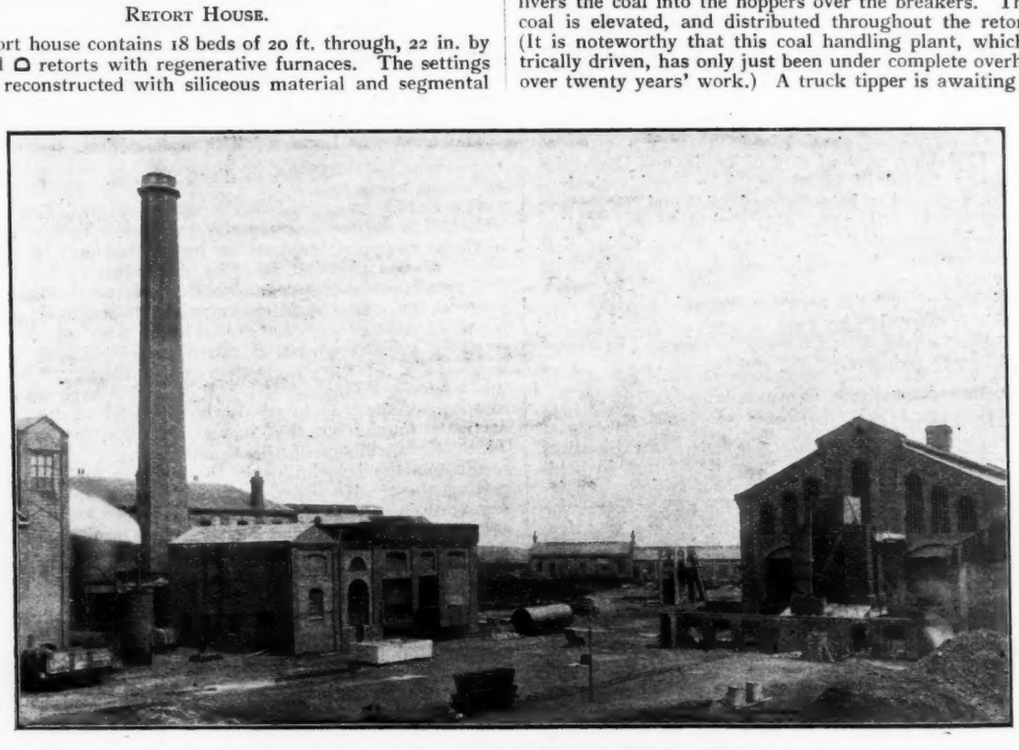
The Glyne Gap Works are situated on a site of 20 acres on the main road between Hastings and Bexhill, and are in the Parish of Bexhill. The sea is in very close proximity. There is direct communication with the Southern Railway (Brighton Section); the nearest port being Newhaven.

The works, which were visited by the Institution of Gas Engineers in June, 1905, and described in the "JOURNAL OF GAS LIGHTING" (May 26, June 2, 9, and 16, 1903; May 31, June 7, 1904), have been in operation over twenty years. The old works in Queen's Road, Hastings, are now used only as a gasholder station and for the distribution department. The design of the works contemplated a power centre for the district, with four units; but only two—viz., one coal gas and one carburetted water gas, with a combined daily capacity of 3 million c.ft.—have so far been erected.

RETORT HOUSE.

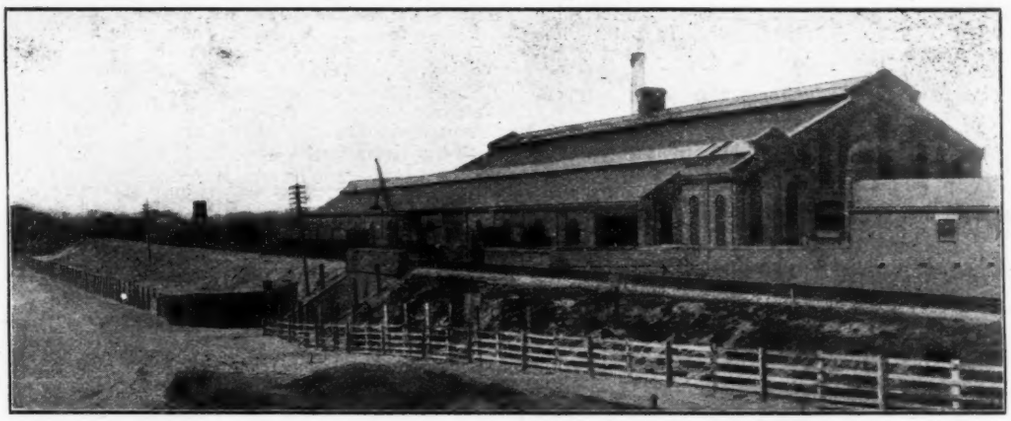
The retort house contains 18 beds of 20 ft. through, 22 in. by 16 in. oval ⌂ retorts with regenerative furnaces. The settings are being reconstructed with siliceous material and segmental retorts. There are continuous overhead coal hoppers, and the following equipment: A Guest-Gibbons charger; a De Brouwer electric projector; a De Brouwer type converted West projector; an Arrol-Foulis hydraulic coke pusher, and a Drakes coke transporter. Tar towers are used (four per bench), and retort house governors.

The coal stores, which have beneath them a storage tank for water, are parallel with the retort house, and have a total capacity of 4000 tons. They can be filled by discharging trucks from a high and a low level railway traversing the whole length, or through the doors in the side wall alongside the siding. A hydraulic lift and a traverser at the one end connect the outer sidings with the yard level and the coal stores lines. The traverser is equipped with weighbridges. All sorts of trucks have to be handled, and in the normal way are discharged into a small coal hopper on the siding, whence a belt conveyor delivers the coal into the hoppers over the breakers. Thence the coal is elevated, and distributed throughout the retort house. (It is noteworthy that this coal handling plant, which is electrically driven, has only just been under complete overhaul after over twenty years' work.) A truck tipper is awaiting erection.



NO. 2 YARD, TAKEN FROM THE HIGH-LEVEL SIDINGS.

On the extreme left is the C.W.G. plant; in the centre, the boiler house; and on the right the west end of No. 1 retort house with the condensing plant. In the middle distance the workshops can be seen.



LOOKING WEST, ON THE FORESHORE.

In the extreme distance the holders of the Bexhill Gas-Works (half-a-mile distant) are discernible. The chief buildings seen are the coal stores, the lift house, and the retort house.

At the east end of the coal stores there is a hydraulic accumulator with two electrically driven hydraulic pumps, so that a portion of the hydraulic system can be used separately if required.

Coke is removed, by means of specially designed narrow-gauge tram skips of 160 c.ft. capacity, either to the coke dock or to the coke yard, or alternatively, by the transporter, on to the experimental coke stage or platform, where it is quenched by means of buckets, and is ready for loading on to road or rail vehicles. No special plant exists for stocking coke, which is an unusual proceeding. At the coke dock there is a hydraulic lift which enables a truck to be lowered into the ground for ready loading. After being tipped from the skips, the coke is finally quenched, and is loaded with forks, in order to eliminate breeze. In the east yard, opposite the retort house, a coke cutting and grading plant, now under reconstruction, is placed alongside one of the yard sidings. There is a full-gauge railway track throughout the works.

At the west end of the retort house water-tube reversible condensers are placed with tar and liquor tank below and a liquor tank above. Stokers' lobbies are also near by. The condensers are connected with the machinery house by a 24-in. main laid in a culvert, which also accommodates other pipes and electrical cables. In this house, which has provision for a recreation room over, there is in addition to twin-exhausters (in duplicate) the following machinery: Steam-driven air compressors in duplicate; small gas engine compressor and an electrically driven compressor (it may be mentioned that the drainage of the works is raised by the Shone ejector system which, *inter alia*, requires compressed air); a 55 KW. steam dynamo; a 55 KW. Westinghouse gas dynamo; a 43 KW. Daimler gas dynamo; a large hydraulic pumping engine; a gas compressor for atomizing oil in the carburetted water gas plant; a 100,000 c.ft. per hour exhauster for C.W.G.; and the blowers for the C.W.G., one being turbine driven and the other belted to a vertical engine which can alternatively be used for driving a 30-KW. electric generator.

Outside the machinery house there is a suction gas plant, and also a hydraulic accumulator. An annexe is being built to accommodate a 100-KW. electrical generating set, which will be adaptable for oil or gas fuel.

The exhausters pump the gas right through the purification apparatus, through a trunk main four miles long, and into the gasholders at Queen's Road.

PURIFICATION PLANT.

The wet purification plant consists of a Pelouze-Audouin tar extractor, a Walker purifying machine, a Kirkham-Hulett washer, and a Holmes rotary washer. (There is a benzole washer—part of the recovery plant, which at present is not in use.) Only oxide is used for purification, and there are separate purifiers for coal gas and carburetted water gas. The former is a continuous box 280 ft. long, with divisions; there being two shallow covers with joints to each section, which sections measure 40 ft. by 32 ft. by 6 ft. deep. The C.W.G. purifiers were removed from the old works, and have water lutes. There are six of these, 30 ft. square. The coal gas is measured by a rotary meter, which is usually in tandem with an 80,000 c.ft. per hour station meter, the latter being specially intended for measuring carburetted water gas. In case of urgency, exhausters at Queen's Road can be used to assist the transmission of gas; but an electrically driven booster is now being installed which will in certain emergencies be used for relieving the back-pressure set up by the trunk main upon the purifiers. The C.W.G. plant, which consists of two sets each of a nominal capacity of 600,000 c.ft. per diem, has the usual pumps and accessories. There are stand-by boilers of the Hornsby water-tube and Cochran types, but steam is ordinarily obtained from the main boiler house. Coke is delivered to the plant in trucks, from which it is loaded into tram skips, which are weighed, and elevated by a hydraulic lift, and can be discharged overhead into a small coke bunker or direct into the generators. The plant, which is due for reconstruction, has one or two special features—notably the system of supplying atomized oil to the carburettors, and a spare generator which can be utilized for either of the two sets. This also enables both sets to be used in winter without difficulty. There are two relief holders of 30,000 c.ft. capacity, and oil storage tanks of 50,000 gallons capacity. In addition to a frictional pipe condenser, there are horizontal water-tube and vertical water-tube condensers.

BOILER HOUSE.

The boiler house, with an octagonal brick chimney 125 ft. high, of special design, is in close proximity to the machinery or power house; the main steam pipes being accommodated in

At the Works Entrance, looking West up the Main Street.

The retort house is on the left, with an experimental coke stage. In the distance are the power house and C.W.G. buildings, and on the right the coke grading and screening plant.

an alley between the two buildings. A large water tank over the boiler house is used for general works supply. There are three Lancashire boilers, 30 ft. long by 8 ft. 6 in. diameter. One is fitted with a superheater, and all have forced draught. Coke and coke breeze are used as fuel, and provision is made for induced draught and for an economizer, which it is hoped shortly to instal. In part of the boiler house the feed pumps, including one electrically driven, are located. It is intended to place water-tube boilers with water-softening plant in an extension of the boiler house beyond the pump room on the west side; but for the time being a liquor concentrating plant is temporarily accommodated in part of this extension. No tar or liquor is stored on the works; the liquor being sent away as concentrated, and the tar practically as produced.

LABORATORY.

The laboratory is usefully equipped. It is the practice to keep average 24 hours' samples of coal gas, carburetted water gas, and mixed gas. Simmance-Abady and Boys calorimeters

are used for spot tests, and there are a recording calorimeter for coal gas, a recorder for carburetted water gas, and a recording gravitometer. In addition to the chemical laboratory and calorimeter room, there are balance and dark rooms, and stores.

The Company have always undertaken much of the constructional work, and do a large amount of plant repairs.

Along the Hastings Road, adjoining the offices, there are shops for blacksmiths, fitters, turners, carpenters, painters, and masons, together with the stores and day-men's lobby.

A new weighbridge, 20 ft. by 8 ft., has recently been installed to meet the requirements of modern transport; and another new weighbridge is being installed upon the high-level siding.

In connection with the old works, the Company had a number of railway wagons, which are not now used for main line traffic. These are most useful for the transport of coke and material about the works, and especially at a time like the present, when so much coal has to be worked out of stock. There are two steam cranes fitted with grabs, and a locomotive which assist in the same matter.

The whole of the gas manufactured, which in 1925 amounted to 560,449,000 c.ft. (2,634,110 therms) is transmitted to the Queen's Road Works for distribution, and is treated by the "Hastings" carburation process, which for so many years has effectively prevented trouble with naphthalene.

A new stove shop with modern equipment is now being erected at the Queen's Road Depot, where the chief showroom, established in 1895, is also located. There are two branch showrooms; and the provision of an up-to-date showroom in a more central position to meet the changed conditions is one among other problems which have to be dealt with in the near future.

On July 1, 1925, the Company absorbed the private undertaking of the Battle Gas and Coke Company. The works at Battle have been closed down, and gas is supplied into the holders there by the ordinary distribution system.

EVENING STAR LODGE, No. 1719.

Emergency Meeting.

W. Bro. Alfred H. Henry, W.M. of the Evening Star Lodge, No. 1719, eloquently voiced the feelings of his brethren of the Lodge when cordially welcoming the Masonic members of the Institution of Gas Engineers who were able to accept the invitation to be present at Freemasons' Hall, Great Queen Street, on Sept. 20, when an Emergency Meeting was held.

The occasion, observed in accordance with a long-established tradition of the lodge, is always warmly appreciated, giving, as it does, the opportunity for brethren from all parts of the country to exchange greetings on the eve of the Institution's Annual Meeting. The prevailing difficulties no doubt accounted for the absence of some. There were, however, about 130 present—members of the Lodge and guests.

During the assembly of the brethren in the Grand Temple, a selection of music on the organ was excellently rendered by Bro. Swan.

The ceremony conducted was that of initiation; the candidate being Mr. Arthur Maurice Bell, Public Lighting Superintendent to the Tottenham District Light, Heat, and Power Company.

At the close of the Lodge, dinner was served in the adjacent Connaught Rooms. Some interesting speeches were made during the course of the evening, and a very enjoyable entertainment programme was provided under the direction of W. Bro. Herbert Townsend.

The Loyal and the usual Lodge toasts were duly honoured; "The Present and Past Grand Officers" being acknowledged by W. Bro. George Eunson, P.A.G.D.C., W. Bro. Lionel F. Dunnett, P.A.G.D.C., and W. Bro. Herbert V. Mitchell, of the Grand Lodge of Victoria, Australia. The latter was accorded a particularly hearty reception. The health of "The Initiate," proposed from the chair, was duly responded to by Bro. Bell. The toast of "The Visiting Brethren" was acknowledged by Bro. John Wilkinson, Senior Vice-President of the Institution of Gas Engineers; W. Bro. H. Butterworth, W.M. of the Northern Star Lodge, No. 3053; and W. Bro. R. P. Vale, W.M. of the Murdoch Lodge, No. 3480.

W. Bro. Henry, in the course of his reply to the toast of "The Worshipful Master," observed that the Lodge would be celebrating its jubilee next year.

The incidents of the evening afforded the greatest pleasure to all who participated; and praise is due to the Secretary, W. Bro. Rae P. Normand, P.M., for the evident attention he had given to each detail, contributing so materially to the success of the evening.

POSITIVE RECORD

GAS CALORIMETER

(*Simmance's Patent*)

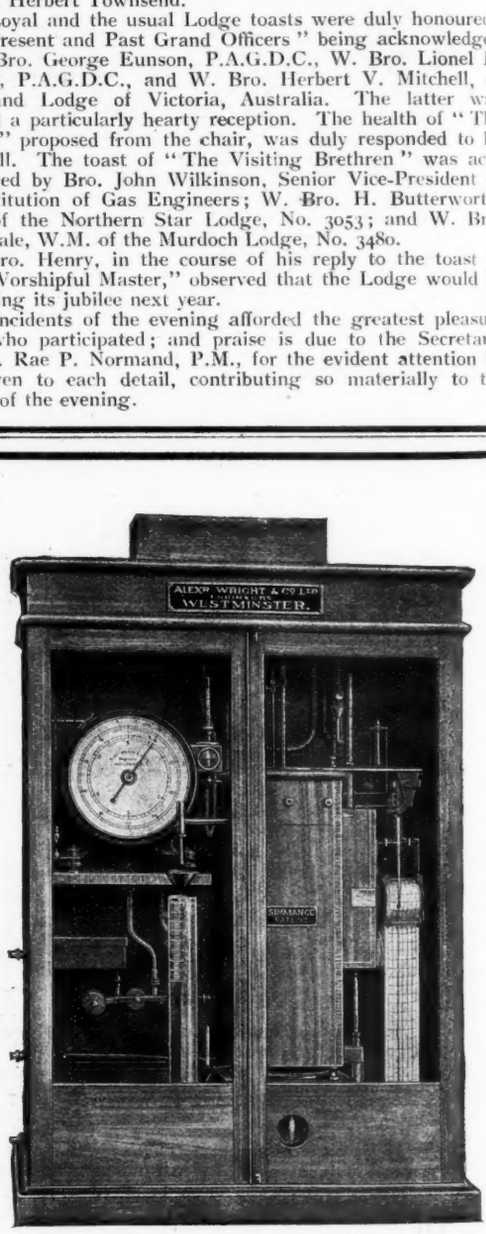
ACCURATE

No Water Troubles.

CERTAIN for a
LONG RUN
without attention.

A PERFECT TEST INSTRUMENT.
A PERFECT RECORDING MACHINE.
AN AUTOMATIC TESTER.

Maintenance Expense Avoided.



ALEXANDER WRIGHT & CO., Ltd., Westminster, S.W.1

Telephone: VICTORIA 1207. Telegrams: PRECISION, SOWEST, LONDON.

GENERAL REPORT OF THE PROCEEDINGS.

THE PRESIDENT, MR. CHARLES F. BOTLEY, M.INST.C.E., IN THE CHAIR.

The President and his Work.

The PRESIDENT (who was cordially greeted), in opening the proceedings, said: Ladies and gentlemen,—My first word to you must be one of hearty greeting, and thanks to you for having managed, in these difficult times, to be with us this morning. I can only hope that our proceedings may prove to be to our mutual advantage. Before I come to the formal business of the meeting, I am going to ask you to give my Chairman your attention for a moment or two.

Mr. W. J. GLENISTER (Chairman of the Hastings and St. Leonards Gas Company): Allow me, in the first place, to express my recognition of the circumstances in which I am attending here to-day. I cannot say that I am here to support Mr. Botley, but, if I may put it so, to testify by my presence to the great respect in which he is held by the Directors of his Company, by the consumers, and I think I may say by the public at large in Hastings and St. Leonards. Mr. Botley is a gentleman who has attained the highest possible position in the gas profession, by his own industry, his own ability, his own application to business, and by the courageous way in which he has met the many difficulties which have beset his path. During the past year he has suffered from a domestic affliction, to which I will not refer; and, in addition to the trying circumstances of the times, he has had to meet, not only during the past year but for many years before that, severe opposition from the municipal electricity undertaking. He has fought with the courage for which he is well known, and has issued from his troubles with credit to himself and to the benefit of the Company and of the public of Hastings and St. Leonards. May I say how much my Directors and I regret that the projected visit of the members of the Institution to our town has been unfortunately, I will not say abandoned, but postponed, because we still entertain the hope that an early opportunity may arise which will enable us to welcome you, as I am sure you would be welcomed, not only by the people connected with the Gas Company, but by the residents of Hastings and St. Leonards generally. I have already spoken of Mr. Botley and his abilities. He is present with us now, and I do not wish to appear fulsome; but I should just like to say that the Board of Directors, the consumers, and the public have the greatest possible personal regard for him and the greatest possible respect for his abilities. We all know how able a man he is; and we feel that, in attaining the position which he has attained of President of this most important and influential Institution, he has not only done honour to himself, but honour to us and our town. I know you have a lot of business to transact, and do not want to detain you longer. I am greatly obliged to you for listening to me, and to Mr. Botley for giving me the opportunity to come here.

Confirmation of Minutes.

The PRESIDENT: The first business on the agenda is the confirmation of the minutes of the last annual general meeting. Is it your wish that these minutes should be taken as read, and that I should sign them as a true record? ["Agreed."]

Appointment of Scrutineers.

The PRESIDENT: The following gentlemen have agreed to act as Scrutineers, subject to your approval: Mr. Octavius Thomas (Pentre) and Mr. A. S. Brook (Lisburn).

Their appointment was unanimously agreed to.

H. E. Jones "London" Gold Medal.

The PRESIDENT: My next duty is a very pleasant one—namely, to ask Mr. George Evetts, M.Inst.C.E., to accept the award now known as the H. E. Jones "London" Medal, for his paper which was so very much appreciated at our meeting last year, on "The Economics of Gas Production on the Thermal Basis." It is quite sufficient if I say that this paper stands as a record to which we can all refer on occasion. It is particularly significant that Mr. Evetts should have received this award at the hands of the Council, because he was associated for many years with our old friend the late Mr. H. E. Jones. It is with peculiar pleasure, Mr. Evetts, that I hand you this gold medal, which I feel you have most richly deserved. [Applause.]

Mr. GEORGE EVETTS: I am naturally very gratified to receive this token of approval from the Council; and my only regret is that the donor of this medal is not here to-day to see me receive it. Just a few weeks before Mr. Jones died, I completed my 21 years' service with him; and I am sure that nothing would have given him greater pleasure than to be here to-day and see this medal handed to me. Thank you very much.

The Diplomas.

The PRESIDENT: I have now to hand over on your behalf the Diplomas in Gas Engineering awarded as the result of this year's examination by the Institution. They are as follows:

First Class, with Distinction.

James Howard Goldsmith, South Suburban Gas Company.

Stewart Lord Wright, Birkenhead Corporation Gas Department.

First Class.

Harold Hirst Thomas, Liverpool.

Second Class.

Sidney Herbert Miles, Reading.

New Honorary Members.

The PRESIDENT: Now we have the nomination for election of the Presidents of various Associations as honorary members of the Institution; and I will ask the Secretary to read the names.

The SECRETARY (Mr. Walter T. Dunn) said: The Presidents for nomination as honorary members are those of the American, Belgian, Canadian, French, German, Italian, Norwegian, Swedish, and Swiss Gas Associations.

The PRESIDENT: I propose that these nominations go forward. Will you kindly signify approval? ["Agreed."]

Mr. H. C. Honey.

The PRESIDENT: The next item on the agenda gives me peculiar pleasure, because I think I suggested the nomination in the first instance. It is the nomination of Mr. H. C. Honey, O.B.E. (late Director of Gas Administration, Board of Trade), as an honorary member. Mr. Honey's name is almost a household word—if I may use that expression—in connection with the gas industry. He will always be identified in the history of the industry with the splendid and conscientious work which he did in connection with the Gas Regulation Act. This was a very difficult task, and I am perfectly certain every one of us who came in contact with Mr. Honey must have cordially appreciated everything he did. Therefore I have much pleasure in proposing that he be nominated an honorary member. I would ask you to pass that with acclamation. [Applause.]

Mr. H. C. HONEY: I very deeply feel the distinguished honour that you have done me by electing me an honorary member of the Institution; and although I know your time is very fully occupied this morning, I must express my gratitude for your vote. For the greater part of my life I have been a public servant; and I am at home therefore in an assembly such as this, which is also composed of servants of the public. ["Hear, hear."] During my official life I have been brought into the happiest relations with members of your profession—men like Sir George Livesey, Sir Corbet Woodall, Mr. Henry E. Jones, and others—whose work, although they are no longer with us, abides; and I have been brought also into the happiest relations with the members of the Institution who are still living. I am therefore very proud to be an honorary member of the Institution.

I want, before I sit down, to congratulate you upon the position which the gas industry now holds in this country. The present one is not the first great national emer-

gency in which the gas industry has played a dominant part. Once again the gas industry has shown that it is an industry of the highest national importance ["Hear, hear"]; and I am rejoiced to think that the part which the industry has played in keeping the country going during the lamentable strike which we have been experiencing for so long has been eminently in the public interest. I congratulate you upon this great achievement, and the President upon the fact that his year of office coincides with a period of which, as I think, it may be said that the gas industry has never done greater service to the country, and has never stood in higher estimation in the eyes of the public. [Applause.]

From Belgium.

The PRESIDENT: We have a communication from Mr. De Brouwer—a familiar name to us—the President of the Belgian Association of Gas Engineers, to the President of this Institution:

> Exceedingly regret circumstances prevent me attending your congress. Belgian gas engineers send you sincere wishes for a successful meeting, prosperity of the Institution, and renewed expressions of friendship from Belgian colleagues.

I take it that we reciprocate these very kindly sentiments, and that we shall be acting in accordance with your wishes if we take steps to do so.

The Reception.

The PRESIDENT: There is one other matter I had better refer to. By an unfortunate slip of the pen, I suppose, in one of the technical papers it was announced that the reception this evening was not to be given. I beg of you all to remember that it will take place; and my family and I will be very disappointed if you are not there to meet us.

An Addendum to the President's Address.

[For the Address, see "JOURNAL" for June 9.]

The PRESIDENT: I see that, according to the order of proceedings, you are now to have some introductory remarks by the President. You have had my address as prepared for the normal June meeting. It has been printed and circulated, so I am assuming that it will at this meeting be taken as read. In the short time which has elapsed since the preparation of the address, however, the march of events has been rapid; and many matters to which reference was made then have received, and are receiving, attention. For this reason, and the extent to which current events may have been reviewed, this addition to the address is given.

The coal stoppage—an incredible folly—continues. Who can measure the loss to this country, and what benefit can it be to those dependent upon the coal industry for their livelihood?

Our industry, in common—let us not forget—with other public utility services, is once more deserving of the gratitude of the nation, and is to be congratulated upon the effective maintenance of the service on which such vast numbers of people are dependent—especially for cooking. Most effective steps were taken in anticipation of the possible trouble, although few can have anticipated that the miners would in the circumstances have refrained from work so long—now over twenty weeks. Many of us would wish to express our indebtedness to all concerned for the steps which have been taken whereby coal is obtainable, although at an increased cost—I might say at a greatly increased cost—and some of it of inferior quality. No efforts on our part should be lacking to keep the flag flying—cost at such a time is not paramount—and so continue to deserve the merit of reliable and honourable service. As far as is known, failures of gas supply are few; and these due probably to political rather than other causes. When one considers that the country is equipped for coal export, but not for coal import, it is really remarkable that such vast quantities have been handled—amounting to upwards of one million tons per week—without more difficulty. As the demand has increased, naturally delays due to this factor are more pronounced, and have given rise to some apprehension.

The Royal Commission's report has not yet been accepted as a determining factor in a very complex matter. Despite some conclusions which were open to serious criticism, there was at first evidence of general acceptance; but subsequently the various interests have used extracts or sections from the report detached from the whole, in order to maintain their own particular point of view. As a representative of an industry using such large quantities of coal, one may be permitted to hold and express definite views. The intervention of the Government from time to time has appeared to be most unfortunate, in a stoppage which arose on economic grounds, because the miners, without having been able to express themselves individually, were called upon to refuse to accept the remuneration which in the various districts the mine owners were able to pay, having regard to market conditions. It is satisfactory to know that legislation has been introduced which, although permissive, makes the hours of working in the mines more flexible. This in many cases seems likely to avoid any alteration in the rates of wages, and coupled with agreements with the parties interested in the various districts should contribute to a settlement. Two other recommendations of the Royal Commission have been given effect to—viz., the establishment of the National Fuel and Power Committee, on which we have two gentlemen well known in the gas industry, and a Committee to consider the Co-operative Selling of Coal.

The Institution is in association with various kindred technical and other bodies, which are now very numerous, and may appear in some cases redundant. There is, for instance, in addition to the Institution of Fuel Economy Engineers, a new Institution of Fuel Technology. It is more and more important, particularly in regard to fuel, that there should be very close co-operation between the Institution and such technical bodies. Thus it is that more active co-operation is being encouraged; and, in conjunction with the Coke Oven Managers' Association and the Society of Chemical Industry (Fuel Section), the Institution is arranging a Tar Symposium at Manchester in November next, and a Carbonization Congress in 1927. Looking still further ahead, the World Power Conference propose to hold a sectional meeting in London in 1928, dealing with the fuel problem. All these conferences, in which it is hoped we of the Institution will play our part, should undoubtedly afford valuable information on various subjects discussed. A Joint Committee of the Gas and Electricity Industries has been set-up for consideration of the many problems which are of mutual technical interest. This, too, is surely a step in the right direction, which it is hoped will bear good fruit.

Circumstances have prevented our visit to the Fuel Research Station at East Greenwich, where, under the direction of Dr. Lander, most valuable and interesting investigations are being continued. Owing to the coal strike, some experiments there are at present in abeyance. A coal washing plant is under construction, and the experimental horizontal setting with provision for dry cooling of coke is ready for use. Fuel Research Technical Paper No. 15 has lately been issued [see "JOURNAL" for Aug. 4], giving results of a test of "Holmside" coal, which is well worth study from the point of view of coal conservation. In a previous Technical Paper details were given of the application of oil to the vertical retort system, which affords very desirable flexibility to that system, resulting in an increase of gas output of 16½ p.ct. by augmenting the steam consumption by about 20 p.ct. and using oil to the extent of 10 gallons per ton of coal carbonized. Further attention is being given to this matter. As investigations are completed, much valuable information will be available.

Reference was made by me in my original address to the possibility of coke oven gas for town supply; but recent experience will naturally have given rise to apprehension. If, in order to make the supply to a district reliable when dependent upon coke oven gas, plant has to be kept ready and coal retained in stock, this will have to be taken seriously into consideration when reviewing such possibilities.

There are now some very fine installations of waste-heat boilers, more especially in connection with vertical retorts. The system has established such confidence that in some works the whole of the steam is supplied from the

plant without stand-by boilers, and there is sometimes surplus steam. When such steam is available, it can conveniently be employed for power through the medium of electricity. The system also is applied to horizontal retort settings and water gas plant, but in all cases needs to be associated with water softening plant. It is, however, easy to get an exaggerated notion of the amount of waste heat available on a gas-works; and it is not always what it may seem at first sight. Some heat energy is required for draught (or ventilation), and the replacement of such by mechanical means may not be economical. It is—and rightly—the modern practice to conserve heat by proper installation of the various plant, and to utilize, in addition to the heat of the waste gases, the hot water from condensers or circulating jackets and exhaust steam. Very often on a gas-works the necessary position of a waste-heat boiler is not the best for the efficient use of the steam produced, although this is a matter which can be corrected when works are designed to utilize the system.

Reference should be made to important steps which have been taken in conjunction with other public service authorities concerning the use of highways for the laying of pipes and the statutory responsibility consequent thereon. With new roads, with the diversion and alteration of existing roads, and the new methods of road construction, the position is a very difficult and involved one. In many cases the breaking-up and reinstatement of road surfaces is now a matter requiring considerable skill, besides being expensive. Anything fresh which can assist to a general agreement is all to the good, and will be welcomed by those responsible in such matters. In this connection, one point may be made—viz., the advantage of close co-operation with the highway authorities and other users of the roads.

A feature of new works and in connection with the modernizing of existing works is that of the handling of materials. Much ingenious and efficient plant is now at our disposal, and there are some outstanding examples where coal, coke, or other material is dealt with by belt conveyors, telpher, or transporter systems. The large coal plant recently brought into use at Beckton, which was inaugurated by Their Majesties the King and Queen, and other recent examples at Fulham and Poole, may be mentioned.

Desirable attention continues to be given to the matter of coke as a solid smokeless fuel. A valuable summary of work to date was presented by Dr. E. W. Smith at the recent Chemical Congress, and particular attention is called to this. Methods of quenching coke by steam in lieu of water and dry cooling are all being tried out. The experimental coke bench at the Glyne Gap Works, which is horizontal, but has obvious limitations, enables coke to be supplied free from breeze and almost bone dry.

The suspension of the supply of home coal should have good influence on the utility of our industry, and emphasize the importance of smoke abatement. In connection with the latter, an exhibition has just concluded at Birmingham, where the case for gas was submitted in a worthy manner both in appliances exhibited and in the papers presented. Many have been forced to rely upon gas for domestic purposes in such a way as never before, and the experience will not be forgotten. Many, too, have used our solid smokeless fuel, coke, in lieu of coal; and, although perhaps not always to the best advantage, have found the usefulness of the fuel. We must see to it that such cases are not forgotten. It is indeed "an ill wind that blows no one any good;" but one would wish that our usefulness could be emphasized without such drastic experiences as the present coal strike. As the result of the strike period experiences, we shall exchange notes with much interest. We shall have information as to various foreign coal, in the matter of both price and quality, and how our undertakings have been influenced as regards the demand for gas and gas appliances, and as to coke. It will be particularly interesting later on to know how far we have been able to comply with all such demands made upon us.

Acknowledgments to Mr. Botley.

Mr. F. P. TARRATT (Newcastle): I feel it is a great privilege that I have been asked to propose a very hearty vote of thanks to the President for his address and his supplementary remarks this morning. You are fully aware of the conditions under which we are meeting to-day; and we are all sorry that he was not able to give us his address in person last June. However, I think you will all agree that he did the right thing in circulating it immediately it had been decided that the Institution meeting must be postponed. I hope you have all read the address, as in it is to be found a very comprehensive survey of matters of great interest at the present moment to the Institution and to the industry. Of course, it is not open to me or to anyone else to discuss the Presidential Address; but if you look through the various headings, I am sure you will find that the President has employed scrupulous care on the address. He must have put into its preparation an enormous amount of labour. The writing of a Presidential Address is not at the present day an easy matter, as there are so many put forward that it is very hard to hit upon anything really new. It will also be remembered with sympathy that during the past twelve months Mr. Botley has laboured under great difficulties. Perhaps I may be allowed to refer to the sad loss that befell him soon after taking the Presidential Chair. We can quite realize how hard it must have been for him, in the circumstances, to apply himself to the preparation of a Presidential Address. However, hard work is probably one of the best things a man can undertake when suffering under such unhappy conditions of strain and anxiety; and probably he has applied himself with additional closeness to the preparation of his address and also to the many other services he has been able to render to the Institution. Mr. Botley, as you are fully aware, has been a member of the Institution for a great many years. He has been one of the most useful members of the Council, and has also done good work on many Special Committees. He has always been one of the men to see that every subject brought forward has full justice done it before a report on the matter has been submitted. We all regret that the visit to Hastings should have been put off, as we should have seen there, as I have seen, testimony to Mr. Botley's ability as an engineer. Although in his address he says that the works are now somewhat out of date, undoubtedly the foundation has been laid for an excellent works, in which ample provision has been made for extension, for modernization, and for equipment in the way we all desire. The name of Botley has always been in our minds closely associated with the town of Hastings. His father was Engineer there for many years; and I am sure Hastings ought to—and does—feel proud of having a man of such character in charge of the gas undertaking. He has had special difficulties to contend with, because in a watering-place everyone is anxious to have the very latest things, and so the competition he has had to face with electricity has probably been rather abnormal; but in spite of this, he has been able not only to maintain, but to increase, the output of gas year by year. I am quite certain he has endeavoured to give good service to the consumers, consistent with the reasonable price charged for the commodity. As you fully appreciate, unless one gives good service it is impossible to say whether the price is a reasonable one or not.

Mr. J. W. NAPIER (Alloa): I second this proposal of thanks with great pleasure and confidence, because of the personality of our President and the valuable characteristics which he possesses and which earn him the affection of all the members of this Institution. The compliment which the Institution has paid him is not an idle one. It is linked up with the honour which the gas industry desires to pay him, because in Mr. Botley I have always recognized—as, indeed, we all have—a striking personality, and a personality which has brought him not only a large measure of success, but a measure of decision and promptitude in duty which have been the admiration of everyone. I do feel that the greatest asset that can possibly be possessed by our industry is the character of the individualism which goes to make it up; and in Mr. Botley we have an exceedingly interesting example of what, in my view, is the true worth of our industry—namely, that character and that outstanding personality which goes to build up the success and the wealth which belongs to the gas industry of to-day. I have very great pleasure indeed in seconding the vote of thanks.

The vote of thanks was carried with acclamation.

The PRESIDENT, responding, said: It is extraordinarily gratifying to hear the kind words which Mr. Tarratt and Mr. Napier have been good enough to say about me as President of the Institution. No man who is human at all can be unmoved by such expressions of cordial appreciation, and I can only sincerely hope that I have really and honestly earned them at your hands. Thank you most sincerely.

Annual Report and Accounts.

[See "JOURNAL" for June 2, p. 460.]

The PRESIDENT: The next business is to receive the Report of the Council for the year 1925-26, and the Accounts for the year ended Dec. 31, 1925. They were circulated in June, the usual date of the meeting, and I would ask somebody to move and second their adoption.

Mr. JOHN WILKINSON, O.B.E. (Nottingham): I beg to move the adoption of the Report and Accounts.

Mr. W. PHILLIPS (Luton): I have pleasure in seconding that.

The PRESIDENT: It is moved and seconded that the Report and Accounts be adopted. Of course, I do not want in any way to prevent discussion on the Report and Accounts, but they have certainly been in your hands for a considerable time, and, of course, if anybody wishes to raise any points, it is now in order for him to do so. I shall be very glad if you will make them at once, before I put the resolution to the meeting.

There was no discussion, and the Report and Accounts were adopted unanimously.

Annual General Meeting of the Benevolent Fund.

The PRESIDENT: We will now take the Annual General Meeting of the Benevolent Fund of the Institution; and I would mention that its position in the order of proceedings shows what importance we attach to this branch of our work. The minutes of the last Annual General Meeting have first to be submitted for confirmation; and I think perhaps it would be well, as it is not often that we have so many present at the meetings of the Benevolent Fund, if the Secretary read them.

The SECRETARY (Mr. Walter T. Dunn) read the minutes of the previous Annual Meeting of donors and subscribers to the fund.

These were confirmed, and were signed by the President.

The PRESIDENT: The report has been circulated to the members with the Annual Report of the Council of the Institution, as usual, and again you have all had time to study its contents. Therefore, I will ask that its adoption be formally moved and seconded, and then it will be open for discussion, if desired.

Mr. J. FERGUSON BELL, J.P. (Derby): I have the greatest possible pleasure in moving the adoption of the Annual Report of the Benevolent Fund Committee. It requires no words from me to commend this to every member of the Institution, and I am very pleased indeed to find that during the past year there has been a renewed interest on the part of the members in this Fund. I personally know what a great amount of assistance and help it has been able to give to members who, through no fault of their own, have experienced adverse circumstances. This is a Fund which was established many years ago by this Institution to help those who unfortunately, through circumstances not of their own causing, were unable to help themselves. It has undoubtedly done good work in the past, and I am certain will do good work in the future. I will not trouble you further than to say that I know of very many instances in which it has meant all the difference between living reasonably and living in great privation; and therefore I have pleasure in moving the adoption of the Report.

Mr. C. S. SHAPLEY (Leeds): I have very much pleasure in seconding the adoption of the Report, and in doing so I will express the hope that the members who have read it will have noticed the valuable work done, and that those who are not subscribers will forthwith become subscribers.

The PRESIDENT: Do any subscribers to the Benevolent Fund wish to offer any remarks or ask any questions in regard to the Fund? I might say that our position this year is largely due to the response made to Mr. Ferguson Bell's special appeal last year. We do not like these special appeals. We think this is a matter which should appeal to every member of the Institution; and if it had not been for the generosity of individuals in the past in providing an investment fund, the interest on which is utilized, we should have been insolvent, as the result of the relief that we have given, some years ago. It has occurred to some of us, in regard to subscribing to the Benevolent Fund, that failure to do so may be due to forgetfulness on the part of members; and therefore, in order that there shall be no need for forgetfulness, we have made special provision in the hall here, so that any who have not already subscribed may have the opportunity of becoming either donors or subscribers. I may say that we who have had the interest of this Fund at heart for so long feel that it is not the few who should give liberally, but that it is the many who should give as they can. We do want to see the Fund entirely independent of the invested funds for its annual outgoings. One never knows what is going to happen, and it has been my experience time and again that those who seek help from the Fund have really been subscribers to it. Well, we naturally hope that none of us will ever come to such a pass, but it is wise, prudent, and only right that we should make provision while we can. With this in my mind I ask you once again to consider the claims of the Benevolent Fund and—those who are not already subscribers—to take the opportunity to put your names on the list. I will now put the resolution to the meeting.

The Report was unanimously adopted.

This concluded the business of the Annual Meeting of the Benevolent Fund.

Report of the Advisory Committee on Education.

The PRESIDENT: The next business is to consider the Report of the Advisory Committee on Education, to be presented by Mr. Goodenough.

[For Report, statement, and discussion, *see later pages.*]

Gas Investigation Committee.

Tuesday morning's proceedings closed with the introduction of the Fifteenth Report of the Gas Investigation Committee, on "Methods of Testing Products of Combustion from Gas Appliances," and the Sixteenth Report, on "Studies in Carbonization—Part I., Influence of Size of Coal."

Prof. Cobb introduced the reports, which were subsequently summarized by Mr. J. W. Wood, M.Sc., A.I.C., and Dr. A. Parker, F.I.C., respectively.

[These reports will be found on a later page.]

Welcome to Colonial Visitors.

The PRESIDENT then introduced to the meeting Mr. A. H. Hewitt, of Toronto, and Mr. H. V. Mitchell, of Brighton, Victoria; and the meeting extended to them a hearty welcome.

Mr. HEWITT, addressing the meeting, said: This is a very great honour. I have felt at home since the moment I arrived in Liverpool on July 26 last, but never more at home than I feel this morning. I am charged to-day with an important message from the American Gas Association. I happen to be a member of the Executive Board of that organization, notwithstanding that I am thoroughly British and from the British city of Toronto. I was in England last in 1912, and I need hardly say that we in Toronto have followed with the greatest interest the progress made since that time, and have felt with you and have gone through with you all those terrible times of distress during the period of the war. It is too late to recall all the incidents relating to that; but you in England, I find, are recovering slowly from the effects of the war, and I am glad to see that you are full of ambition and full of determination to rise above all difficulties, even the coal strike. I am sorry that you are having to import so much coal from America and from European ports. "Carrying coals to Newcastle" used to be regarded as a joke, but it is no joke to-day, Mr. President; it is the real thing. And when I heard you refuse to discuss the coal question this morning, I felt a little glad, because it

indicated that you are going to deal with the facts as you find them from day to day. I congratulate you, Mr. President, on the completion of a very successful year of office. I have been with one Company for forty years—I am just finishing my fortieth year—and I appear before you to thank you for the heartiness of this welcome. I can speak for the American Gas Association and also for the Canadian Gas Association, for the Secretary of my Company this year is the President of the latter body; and I shall go back with feelings of great pride that it has been my privilege once again to attend a meeting of the Institution of Gas Engineers in Great Britain. My previous visit in 1912 happened to be in June. I had not thought very much about the meeting of the Institution, but I was fortunate in being able to attend the annual meeting that year; and I want to thank you, Mr. President, for having postponed this year's meeting from June until September, that I might again have an opportunity of attending and of taking part in your deliberations. [Laughter.] I am proud indeed to see the way in which you tackle your problems. You even take University professors into your confidence. Some of them are afraid of us. [Laughter.] The trouble is, you know, that they stick too close to facts; and the gas business has not learned to stick close enough. However, we can learn a good deal from University professors. This year I happen to be President of the Royal Canadian Institute, and I am the only layman on the whole Council. Prof. Banting, of insulin fame, and the head of the Department of Physics in Toronto, and Prof. McLellan, whom you know pretty well in London, are on the Council, and they have elected a layman as their President for this year. All the others are, I was going to say "high-brows," but they do not like that term. However, that is another office that I am at present filling, and this meeting has a measure of attraction for me because of what the professors have had to say about the gas industry, and because they reveal, in their search for truth, facts not at present revealed to the gas industry. [Applause.]

Mr. H. V. MITCHELL: I should like to take this opportunity of thanking your President for his courtesy in inviting me here, as well as your indefatigable Secretary, who extended the right-hand of friendship to a visitor from overseas. I have enjoyed your deliberations very much indeed. I bring to you, Mr. President and gentlemen, greetings from the Australian Institute of Gas Engineers. We feel that we owe you a very great debt of gratitude, because the bulk of the things we are enjoying over there in the way of gas, especially gas scientifically applied, emanates from this great Institution of Gas Engineers of Great Britain.

The meeting adjourned for luncheon.

Greetings from the French Society of Gas Engineers.

When the proceedings were resumed after the luncheon adjournment, the President announced the receipt of a telegram from the French Society of Gas Engineers, as follows:

> "The President and Members of the Committee of the French Society of Gas Engineers send to their English colleagues meeting in London their best wishes for a successful conference, and their cordial sympathy."
>
> (Signed) ROLLAND D'ESTAPE, President.

The PRESIDENT: The word "sympathy," of course, you will understand, refers to the anxious time through which we are passing, having regard to the suspension of coal supplies. I take it I shall be in order in reciprocating this cordial expression of feelings from our French colleagues. I can assure you that during my time of office our relations with all these kindred associations abroad have been most cordial; and I therefore purpose to send, in your name, a reciprocal message in response to this.

This course was agreed to.

Later, the President explained that he had received a letter from the President of the Société Technique de l'Industrie du Gaz en France, who said how sorry he was to be unable to attend the meeting.

Portslade (Brighton) Gas-Works.

The afternoon was devoted to the reading and discussion of a paper by Mr. C. H. Rutter, M.Inst.C.E., on "The Development and Reconstruction of the Portslade (Brighton) Gas-Works." This is given on a later page.

New Members.

The PRESIDENT: The first business this morning is to welcome those new members of the Institution who may be present. I will ask the Secretary to read out the names.

MEMBERS.

Aitken, H. A., General Manager, Gas Works, Leven, Fife.
Barrett, Charles Gerald, Chief Assistant Engineer, Gas Works, West Hartlepool.
Blake, Thomas Vincent (Institution's Diplomé in Gas Engineering, 1925), Technical Assistant and Chief Chemist, Gas Works, Cardiff.
Bottomley, Joe William, Engineer and Manager, Gas Works, Milnrow.
Brockway, Fred Garrett, Engineer, Manager, and Secretary, Gas Works, Cleethorpes.
Bullmore, A. W. E., Engineer, Gas Works, Letchworth.
Dyson, Thomas (Institution's Diplomé in Gas Engineering, 1925), Works Superintendent, Huddersfield Corporation Gas Department.
Ellis, George William, Manager, Gas Works, Berkhampstead.
*Goldsmith, James Howard (Institution's Diplomé in Gas Engineering, 1926), Works Assistant, Sydenham Station of the South Suburban Gas Company.
Halliwell, Jesse Ormston, Engineer and General Manager, Irish Midland Lighting Company, Mullingar, Ireland.
Hornby, Percy Hulme, Chief Assistant Engineer, Gas Works, Southall, Brentford.
Hudson, Beaumont, Engineer and Manager, Gas Works, Pontefract.
Hultman, Gustaf Henrik, Chief Engineer, Gas Works, Stockholm.
Lacey, Leonard, B.Sc. (Eng.), Assistant Engineer (Resident), Stratford Works of the Gas Light and Coke Company.
Morrison, James, Engineer, Gas Works, Ballymena, Ireland.
Reece, Thomas Henry, Engineer, East Kent Gas Company.
Rooney, Joseph Agustine, Engineer and Manager, Gas Works, Drogheda, Ireland.
Shewring, Harold, Engineer and Manager, Gas Works, Rochdale.
Simmonds, Vernon, Assistant Engineer, East Greenwich Station of the South Metropolitan Gas Company.
Sutcliffe, Herbert, Manager and Secretary, Gas Works, Gowerton.
Watson, Peter Mountain, Manager, Gas Works, Cleveland.
Yates, Arthur Farrar, Engineer and Manager, Gas and Water Works, Goole.

ASSOCIATE MEMBERS.

Akroyd, John Edwin, Assistant Manager, Great Western Railway Gas Works, Swindon.
Calderwood, Robert Wallace, Assistant to Engineer and Manager, Gas Works, Spalding.
Canning, T. Anthony, Assistant to Engineer and Manager, Gas Works, Dewsbury.
Clarke, Bernard, Assistant Engineer, Gas Works, Long Eaton.
Dunbar, Harry Clifford, Assistant Manager, Gas Works, Hemel Hempstead.
Escreet, Hubert John, B.Sc. (Eng.), Assistant Distributing Engineer, Gas Light and Coke Company.
Galleway, Harold, Assistant Manager, Gas Works, Whitby.
Kirkhope, John, Shift Chemist, Tottenham District Light, Heat, and Power Company.
*Le Fevre, Reginald Nelson, Draughtsman and General Assistant in Distribution Department, Gas Light and Coke Company.
Maitland, William Barclay, Works Superintendent, Gas Works, Malta.
Pallister, John Walton, Technical Assistant, Gas Works, Middlesbrough.
Risby, Harry James, Technical Assistant, East Greenwich Station of the South Metropolitan Gas Company.
Shadbolt, Robert, Assistant Engineer, Gas Works, Ascot.
Skinner, Alec George, Engineer's Assistant, Gas Works, Redhill.
Smith, Ernest Philip, Assistant Engineer, Gas Works, Chelmsford.
*Smith, Joseph Frank, Senior Technical Assistant, Gas Works, Leamington.
Thorpe, Benjamin, Chief Chemist, Huddersfield Corporation Gas Department.
*Weaver, Leonard John, Technical and General Assistant, Gas Works, Dover.

*Williams, Rowland Joseph, Assistant Engineer and Manager, Gas Works, Abertillery.
*Wright, Stewart Lord, Junior Assistant Engineer, Gas Works, Birkenhead.

ASSOCIATE.

Benham, Harold Francis, Assistant Engineer, Messrs. L. Askew & Son, Westminster.

* Formerly a "Student."

The President then introduced such of the new members as were in attendance.

Further Telegrams.

The PRESIDENT: I have one or two telegrams to bring to your notice. I am sorry I omitted to mention yesterday that Mr. H. Pooley, of Leicester, a member of the Council, in the present circumstances of the coal situation has been unable to come to the meeting. He has been good enough, however, to send a telegram in which he hopes that we shall have a very successful meeting. To-day, we have a telegram from the Italian Institution of Gas Engineers, wishing continued prosperity to our great industry. We also have a cablegram from the American Gas Association: "Greetings and felicitations of American Gas Association. May your annual meeting be most successful." I am sure you will wish us to reciprocate these kindly feelings.

List of New Officers.

The PRESIDENT: The Scrutineers' report is in my hands, and the result of the ballot is as follows:

President.—Mr. John Wilkinson, O.B.E., of Nottingham.

Vice-President.—Mr. J. W. McLusky, of Glasgow.

Auditors.—Mr. S. Y. Shoubridge, of Eastbourne, Messrs. Wood, Drew, & Co., of London.

Hon. Secretary.—Mr. W. E. Price, of West Chobham.

Ordinary Members of Council.—Messrs. J. H. Canning, of Newport (Mon.); W. E. Caton, of Oxford; P. G. G. Moon, of Bournemouth; and H. C. Smith, of Tottenham.

Benevolent Fund Members of Committee of Management.—Messrs. John W. McLusky, of Glasgow, and Robert Robertson, of Bristol.

Carbonization in Continuous Verticals.

An "Investigation of Some of the Factors affecting Carbonization in Continuous Vertical Retorts" was described by Mr. T. F. E. Rhead, M.Sc., A.I.C. For the paper—*see later page.*

A Warning.

During the discussion on Mr. Rhead's paper, the President called on Mr. Thomas Glover (Lord Mayor of Norwich) to say a few words.

Mr. THOMAS GLOVER, in the course of a short speech, said: I had a very heavy Council meeting yesterday which lasted until 7 o'clock; and therefore I could not be in my place here yesterday. I should like to mention that in the development of electricity supply in the immediate future we are up against a big thing. Costs are continually coming down, owing to the improved load factor due to increasing power supplies; and what we must appreciate is the constant and successful endeavours on the part of the electrical industry to secure the heating load and the cooking load. When I look at the figures of the gas industry, I know that we are in a strong position; but I think it is up to all of us not to minimize what the electrical people are doing. We should take very great care to watch them. We must be prepared by efficiency and by attention to the consumers' requirements to fight the straight fight, as we hope they will do.

Refractory Materials Report.

The report of the Refractory Materials Joint Committee was presented by the Chairman, Mr. J. P. Leather—*see later page.*

Service to Consumers.

A joint paper on "Service to Consumers" was presented at Wednesday afternoon's sitting by Mr. John W. McLusky, of Glasgow, and Mr. W. B. McLusky, of Halifax—*see later page.*

The PRESIDENT: I am pleased to have with me on the platform Bailie James Paterson, the Convener of the Glasgow Corporation Gas Committee, and also Alderman Waddington, the Chairman of the Halifax Corporation Gas Committee. Needless to say, these gentlemen give the greatest possible support to our colleagues, who, without this support certainly could not be efficient in the discharge of their duties.

Gas Research Fellowship Report.

Prof. Cobb introduced the Gas Research Fellowship, 1926, Report, dealing with "The Influence of the Ash Constituents in the Carbonization and Gasification of Coal—Part II., Gasification of Special Cokes in Steam," by Dr. C. B. Marson, M.Sc., A.I.C. (Gas Research Fellow), and Prof. J. W. Cobb, C.B.E., B.Sc., F.I.C. (Livesey Professor)—*see later page.*

Thursday morning's proceedings opened by Dr. Marson giving a résumé of the report—*see later page.*

Gas Distribution at High Pressure.

The final paper submitted was on "The Distribution of Gas at High Pressure," by Mr. Arthur W. Sumner, A.M.Inst.Mech.E., of Grays—*see later page.*

The New President.

The PRESIDENT: You will have seen from the report of the Scrutineers, already announced, that Mr. John Wilkinson, of Nottingham, is the new President—[applause]—while the new Vice-President is Mr. J. W. McLusky, of Glasgow.

Mr. JOHN WILKINSON (Nottingham): Please allow me to express my sincere and grateful thanks to you for having done me the honour to elect me your President for the ensuing year. I am deeply grateful to you for the confidence which you have reposed in me. I realize the importance of the position; and I can assure you in all sincerity that I will give of my best, provided that I enjoy good health.

Presidential Certificate.

Mr. WILKINSON (continuing) said: I have just been informed, Mr. President, that the services during your period of office are to be dealt with in the form of a special resolution, which I am pleased to note is to come from the body of the hall; but I feel that I must take this opportunity, on behalf of your colleagues who have served with you on the Council, of expressing our sincere thanks, and also our admiration for the manner in which you have conducted the affairs of the Institution during the past fifteen months. ["Hear, hear."] It has been a very difficult time in more ways than one; but you have done one thing, if you have done nothing else, and that is you have cemented together more tightly than ever before the bond of good fellowship among the members of this Institution. We have served with you during these past fifteen months in circumstances which, in more directions than one, have been exceedingly difficult; but the greater the difficulties and the strain, the greater have been the energy and the determination which you have infused into your work. We are truly sorry to lose your services and your guidance; but we realize that Presidents must come and Presidents must go. In handing you this certificate, I would say that, if in future days it brings to your mind as happy recollections of your colleagues on the Council as they will have of you, then some recompense will come to you for all the arduous work you have done. [Applause.]

The PRESIDENT: You have heard Mr. Wilkinson speak of my services in most eloquent terms. It is very difficult, especially in a more or less public meeting, to express one's thoughts in words appropriate to an occasion such as this. It would, however, be most ungracious on my part if I did not in the first place refer to the loyal and courteous help that I have always received from my friend Mr. Wilkinson. Certainly I can say, without fear of contradiction or doubt, that no President was ever more loyally served than I have been by both my Vice-Presidents. I believe that no man treads the course of office as President of the Institution without leaving a mark one way or the other. It has been said over and over again during the course of this meeting that the mark I have left is one worthy of the Institution. That in itself is extra-

ordinarily gratifying; but believe me, it leaves a mark on me also. I can never forget the comradeship I have experienced; and if, in circumstances perhaps not often paralleled, human sympathy has come to the aid of our professional fellowship, and it has helped this Institution, it is indeed a great reward. One other matter I might be permitted to mention. This presentation, which will be a great source of pride to my family, will probably be ranged alongside something else which I have received during my year of office, and to which I attach the greatest importance. I have very great regard for those with whom I am associated in my work at Hastings; and many of them have been with me for over a quarter of a century, and have given me most loyal and devoted service. Very greatly to my surprise, but to my intense gratification, about a year ago they presented me with a testimonial in recognition of my being President of the Institution. So these fellow-workers of mine have identified themselves with my progress in the affairs of the Institution. I have but one more word to say, and it is this: I have tried to hold the Institution high. I have tried to see that its functions were not trespassed upon; and I would commend to my good friend our President-Elect the steps which I have endeavoured to take. Gentlemen, believe me, I am extremely grateful.

Votes of Thanks.

The PRESIDENT: We are nearing the end of our business; but I have taken upon myself the duty of proposing a vote of thanks, which I trust you will think does not inappropriately come from the President. It is a composite vote of thanks to the Council, the Hon. Secretary, the authors of papers, the Research Committees, the Scrutineers, and the Auditors. If I pass over the various phases of the resolution somewhat briefly, do not think that I am wanting in any sense of gratitude for services rendered. I have already partly indicated my personal views on what is due to the Council; but now I am trying to express the views of the members, who, I know, thoroughly appreciate how deeply indebted they are to the members of the Council. The President bases his opinions largely upon information presented to him by the representatives of the various districts; and during the past fifteen months the Institution has been well served by the members of the Council. With regard to the Hon. Secretary, as he is a dear old friend of mine it is difficult for me to speak as I should like; but Mr. Price is an asset to the Institution. To put it in his own way, he "breaks the Presidents in." I do not know how much trouble I have given him. But, joking apart, Mr. Price is a man you would wish to have with you, to support you in your year of office; and with that kindness of heart and wonderful tact for which he is noted, he plays the part allotted to him in a manner which is above commendation. It is particularly appropriate that I should voice the thanks of the Institution to the authors of the papers, because they were presented in response to my personal application. I chose the subjects as suitable for this meeting. I am sure you are all grateful for the time and attention bestowed on the preparation of the papers, and for the valuable information which they contain. The Research Committees continue work which has been in the past of incalculable value to the Institution; and we are indeed indebted to them for the time given—all of it honorary, remember, in the service of the Institution. The Scrutineers, I trust, have done their work to your satisfaction—certainly they have in announcing Mr. Wilkinson as President—while the Auditors have found the accounts, as prepared by Mr. Dunn and his Assistant, Mr. Winder, in perfect order.

Mr. H. J. RANDALL (Blackwater): I have much pleasure in seconding this vote of thanks. After the eloquent speech of the President, nothing remains for me to add, except that, as a very humble member of the Institution, I have been deeply impressed with the high quality of the papers this year. I feel each one of us will go back to his work feeling prouder than ever of being a member of this Institution. [Applause.]

Mr. H. D. MADDEN (Cardiff): On behalf of the Council, I thank you very much for the vote. I can only say that the work in the past year has been a great pleasure. The President has been extraordinarily keen on all the subjects that have come forward. Any thanks you may accord us, we are glad to receive; but we have been very pleased to do the work which the President has called upon us to do. We shall give Mr. Wilkinson the same loyal support that we have accorded Mr. Botley.

Mr. W. E. PRICE (West Chobham): As things were originally planned, I was put down to answer for the lot. Now you see that the office of Hon. Secretary has its uses, because at the last moment he is called upon to correct the errors of others. [Laughter.] Still, it is left to me to respond under more than one heading. I should like to say, with reference to members of Committees, that they are all very keen on their work. Committee meetings are held almost every week, and therefore thanks are certainly due to the members. Speaking for the Committees, we thank you for your recognition of the work we have done. You are evidently satisfied with the Auditors, because there was no discussion on the report, which included the balance-sheet. As to my humble self, if I can do any work for the industry, and if you wish me to continue what I do for the Institution, I will carry on. But I still think, as I have said before, that a younger man with more energy should come along and take over the reins very shortly. I do not think it is right that one should hold such an honourable office for an indefinite period; and I can see many round me who could do what I have done. I am, however, grateful to you for the way in which you look upon my services.

Mr. JOHN W. MCLUSKY (Glasgow): I am to say a word for the paper readers now. I do not know why I should have been selected, because I really did not read a whole paper, but only half of one. I was just one of "the McLusky brothers." [Laughter.] But, speaking seriously, if one goes at times through the "Transactions" of the Institution, and studies matters that have been discussed, one must feel that to be a paper reader—to be associated with that long gallery of men who have contributed papers—is a great honour and a great privilege. It is not a matter of being thanked for reading a paper. It is a very great compliment to be asked to come here and tell your professional brethren about something you have tried to accomplish—which information in the main is very well received and very kindly treated. That is how I regard the matter; and I feel sure the other paper readers will, with me, look upon the honour done them as more than ample reward for their efforts.

Mr. MADDEN: Before we part, there is just one other resolution which I have been asked to put forward, and that is a vote of thanks to the Institution of Civil Engineers for their courtesy in granting us the use of this building for the purposes of our annual meeting. We appreciate the privilege very highly. This is the home of engineering; and it is only meet that when such hospitality is offered us, we should accept it.

Mr. W. S. MORLAND (Gloucester): It is a great pleasure to me to second that.

The resolution was unanimously carried.

Place of Next Meeting.

Mr. WILKINSON: With regard to the place of next year's meeting, I may say that illness has unfortunately prevented my Chairman, Alderman Sir Albert Hall, from being present this morning, to extend to you a hearty invitation to make Nottingham your place of meeting next year. But I will speak quite frankly, and say that in my opinion the best interests of the Institution will be served by holding the meeting here in London—and perhaps arranging a trip to Nottingham on the Friday. My view is that the business meeting should take place in London.

The PRESIDENT: Though this question is usually brought before the meeting, I think you will agree with me that it is largely one for the President to decide. But while leaving Mr. Wilkinson to have the final word, it will perhaps help him if I ask you to signify whether you approve of his suggestion, without binding him.

Mr. SAMUEL GLOVER (St. Helens): May I propose that we send a message of thanks to Alderman Sir Albert Ball for his kind invitation to Nottingham, and suggest that we should hold the meeting in London, with possibly a visit to Nottingham.

Mr. W. J. SMITH (Bolton) seconded this, and it was agreed to.

The Secretary.

The PRESIDENT: There is another resolution which I wish to propose, because it vitally concerns the President—namely, that a hearty vote of thanks be tendered to the Secretary (Mr. Walter Dunn), his Assistant (Mr. J. H. Winder), and the other members of the staff, for their services during the past year. I can testify that the work of the Institution has received splendid attention throughout my year of office. I can assure the members that we are well served by our officers. Nobody could have been more helpful than Mr. Dunn has been to me, and nobody knows so well as I do the amount of work which I have called upon him to do.

Mr. PRICE: I shall be very pleased indeed to second that proposition. I think perhaps I am as well qualified as anyone to do so, for the reason that I know the work which is being done. What the President has said is in no way an exaggeration. There has been a lot of work to do, and it has been very well done. [Applause.]

Mr. DUNN: I thank the President and Mr. Price very sincerely for what they have said. Whatever I and my staff can do, is most heartily done, and we hope we shall continue to deserve the good opinions which have been expressed.

The President's Services.

Mr. THOMAS GLOVER (Norwich): There is just one remaining duty to discharge, and that is to thank the retiring President with all our hearts for his great services to the Institution during the past year. The demands made upon the President's time, strength, tact, skill, and purse are very great, and Mr. Botley has risen to the occasion in the most splendid manner. As our new President, Mr. Wilkinson, has already pointed out, it has not been by any means a normal year. It has been a difficult period; but the work has been exceedingly well done. I have no doubt there have been numerous Council and Committee meetings, at which Mr. Botley has been present, and which he has ably guided. We are very grateful to him; and I have great pleasure in moving that the best thanks of the Institution be recorded for his services during the year, and for the reception which he gave us on Tuesday night. The reception was, I believe, enjoyed as much as any previous reception held by a President of the Institution. It was a brilliant function; and the members would wish to take this opportunity of thanking the President for his liberality on that occasion.

Mr. J. E. BLUNDELL (Carlisle): I am glad to have the honour of seconding this resolution. I have followed right through the year everything our President has done; and I can only express, what other speakers have already expressed, admiration for the manner in which Mr. Botley has filled the chair. He has from the beginning upheld the highest and the best traditions of the office. We thoroughly enjoyed ourselves at the reception, and we are very anxious that the President should know, and that his daughter should know, that we did so. It must have been gratifying to the President, and a proof of our loyalty to him, to note how well attended the sessions have been right up to the last hour of the meeting. [Applause.]

The PRESIDENT: I think the words we have just heard from Mr. Glover and Mr. Blundell, with their evident mark of sincerity, must be taken by myself and by my family, who are present, as the culmination of a very strenuous and a very happy time. I do take it, gentlemen, believe me—although above all I hope it is in the interests of the Institution, and to the benefit of the Institution—as an act of great personal loyalty to me that you have been so patient and regular in your attendance, particularly in the prevailing circumstances.

I will bring the session to a conclusion by wishing you God-speed and every success, and by urging you to the highest endeavour in carrying on our great industry, not only to your personal credit, but to the great service of the British nation.

DOUGALL'S IMPROVED : PATENT : AUTOMATIC METER

READY FOR IMMEDIATE DELIVERY.

STRONG. ACCURATE. POSITIVE.

Valve actually opens at 5 ft.
without aid of spring.

PRICE CHANGING—
SIMPLICITY ITSELF

DOUGALL'S GAS METERS LTD.

STRAND-on-the-GREEN, LONDON, W. 4

Telegrams: "Increasing, Chisk, London." Telephone: Chiswick 1965.

EDUCATION SCHEME.

REPORT OF THE ADVISORY COMMITTEE FOR THE YEAR 1925-26.

Introduction.—The year 1925-6 has been one of steady progress and development. This has not been quite so great as had been hoped and expected, but yet is sufficient to afford encouragement. The facts that seven additional Technical Institutes have had approved Courses in Gas and ancillary subjects approved during the year, and that the number of candidates for examination in 1926 has gone up to 162 as compared with 108 in 1925, an increase of 50 p.ct., are evidence of steady progress.

The full list of Institutes and Colleges giving Course instruction under the Institution's scheme is set out in the appendix to this report.

Entrants for Examination.—The distribution of the present year's candidates for examination by subject and grade is as follows, the corresponding figures for 1925 being also given for the purpose of comparison:

1925.	O.E.	H.E.	D E.	O.S.	H S.	Totals.
Internal candidates .	28	17	—	6	1	52
External ,, .	30	10	7	7	2	56
	58	27	7	13	3	108
1926.						
Internal candidates .	54	26	—	16	2	98
External ,, .	23	12	7	19	3	64
	77	38	7	35	5	162

The internal candidates are being sent in from 13 Technical Colleges or Institutes, as against 8 which presented candidates last year.

Increase in College-Trained Candidates.—A feature of special interest in the examination list this year is the great increase in the number of College-trained candidates. While the number of external candidates remains about stationary, there is an increase of nearly 90 p.ct. in the College-trained class. This is of good augury for the quality of the candidates and for the welfare of the industry, as, other things being equal, the College-trained man must always be preferred to the self-instructed or the partially trained.

Wide Areas not Supplied with Classes in Gas Subjects.—It is rather disappointing to find that 13 of the Colleges having approved courses have no students sufficiently advanced to take the examinations this year, and that two others have been unable to run classes this session in either Gas Engineering or Gas Supply, owing to lack of students. Serious as this is in itself, it becomes still more so when we consider how very few Technical Colleges throughout the country have approved courses. Taking a line from Leeds to London, there is not one approved course to the east of that line. If we take another line from London to Bristol, there are only three approved courses to the south of that line. Taking yet another from east to west through Leeds and Blackburn, the only approved courses from that line to John o' Groats are those at Glasgow and Edinburgh. There are only 6 entrants for the 1926 examinations from Glasgow, and none from Edinburgh. This is very far from satisfactory. The reason is, of course, the absence of students. The Board of Education and many local authorities are very willing to arrange classes if students are forthcoming.

Pressure and Facilities.—It therefore appears that one of the problems the industry has to solve is how to ensure the regular flow of students in the numbers which its future welfare demands. In the judgment of your Committee there must be greater pressure exerted and greater facilities offered in order to obtain this result. Legitimate pressure may be applied in the following ways:

(*a*) By means of compulsory clauses in all articles and indentures, from those of the apprentice gas-fitter to the articled pupil.

(*b*) By making promotion dependent far more largely than at present on progress in technical studies.

(*c*) By encouraging success in technical study by increases in wages or salary.

Facilities may take the form of—

(*a*) Time allowance. Necessary as this is where studies may be taken in the town of residence, it becomes imperative when journeys have to be taken for tuition. Time off makes it possible to secure afternoon and evening lectures for one railway fare.

(*b*) Payment of travelling expenses or class fees, or both, on a basis of attendance or examination results.

Theses Submitted by Diploma Candidates.—In accordance with requirement 4 in connection with the examination for the Diploma in Gas Engineering, the theses of the seven candidates have been received. The subjects treated are as follows:

1. "Methods of Coal Carbonization, being Minor Works Improvements made Practicable by a Systematic Investigation of Irregularities in Working."
2. "Some points in the Design and Operation of Horizontal Retort Settings."
3. "Mains on Gas-Works."
4. "Notes on the Drying and Heating-up of Retort Settings."
5. "Carbonization, Present and Future."
6. "The Effect on the Gas Making Value of Gas Oil of its Previous Use for the Removal of Naphthalene from Coal Gas."
7. "The Use of External Producer Gas for Heating Retort Settings."

Conference with Teachers.—In order to link up more closely the Teachers of Gas Engineering and Gas Supply throughout the country with the Advisory and Consultative Committees, and to discuss various points of interest in the working of the Education Scheme, a Joint Conference was held at Grosvenor Gardens last December. This proved so highly successful that it was unanimously decided to repeat the experiment before the commencement of another Session.

Relation of the Major to Minor Grouped Courses.—A little confusion on the part of students and others appears to be creeping in as to the relation between the Major Grouped Courses in Gas Engineering and Gas Supply and the Minor Grouped Courses in Gas-Works Practice and Gas Supply Practice. A Sub-Committee has therefore been appointed to consider this relation and, if necessary, to redraft the Syllabuses in order to differentiate more widely than hitherto as between the two sets of courses. Although the Committee has not finished its work as yet, sufficient has been done to prove that it will be necessary to recast the syllabuses. It is felt to be especially desirable that these should indicate clearly to students and teachers alike that the examinations in Gas Engineering and Gas Supply would, in future, have more definite relation to the ancillary subjects taken in the course, and that the question papers set would be so framed as to test the knowledge of the candidates in these subjects.

Position of Scottish Students.—Another important matter which has been engaging the attention of the Committee is the question of tuition in ancillary subjects of the more or less isolated students in the sparsely occupied areas in Scotland. As the result of a Conference of the Joint Councils of the Junior Gas Associations of the Eastern and Western Districts and the Scottish Committee of Advice, held in January, which was attended by the Organizing Secretary, a small Committee was appointed to consider further the question in all its bearings, in conjunction with the Scottish Education Authorities. It is hoped that the work of the Committee will result in additional facilities being afforded in far more centres than at present for instruction in ancillary as well as the main subjects.

The Adult and Experienced Gas Fitter.—The Advisory Committee has also considered the position of the adult and experienced gas-fitter who desires certification, but who, for good and sufficient reasons, is unable to take now the full Gas Fitting Course adopted last year. In order to meet what were felt to be hard cases, the Committee have decided that for the years 1926 and 1927 such candidates may be admitted to the Final examination, providing that the candidate is not under twenty-five years of age on Jan. 1 preceding the date of the examination.

Conclusion.—In conclusion, taking a general review, the record of work done and progress made, considered alone,

shows much ground for encouragement. When, however, these are contrasted with the needs of the industry, the Committee are conscious of the large amount of work which must yet be done before the Education Scheme can take the place in the organization of the industry which its importance demands.

APPENDIX.

Bath; Barnsley; Birmingham; Blackburn; Bournemouth; Bradford; Bristol (Merchant Venturers); Burnley; Cardiff; Coventry*; Derby; Dewsbury; Edinburgh (Heriot-Watt); Glasgow (Royal); Halifax; Huddersfield; Liverpool; Leeds; East Ham; London: Regent Street Polytechnic, Tottenham Polytechnic, Sir John Cass Institute, Westminster Institute; Manchester; Plymouth; Portsmouth; Salford; Stoke-on-Trent; Walsall; Wolverhampton*.

Mr. F. W. GOODENOUGH, C.B.E. (Chairman of the Committee): It is my privilege to present to you the Report of the Advisory Committee on Education for the past year. The note of that Report is struck in the first lines, where it says that the year has been one of steady progress and development—not so great as might have been hoped, but sufficient to be encouraging. It is obvious that a scheme which involves a five-year course in order to obtain the Final Certificate by students who have no exempting qualifications is not going to be taken up instantly by all the young members of the industry; but the progress that is being made is very decided, and I think, taking all the circumstances into account, can be regarded as encouraging. Of course, there are four parties to the success of the Education Scheme. There is first of all the Institution, which founds the scheme and provides the machinery for carrying it out; next there is the Board of Education, which co-operates with the Institution both in devising and in carrying out the scheme (and I would like again to pay the warmest tribute to the value of the assistance that we, as an Advisory Committee, get from the representatives of the Board of Education, who are extremely valuable and who devote themselves to the work with the closest possible attention and enthusiasm); then there are the students themselves; and finally, and by no means of least importance, there are the employers in whose service the students are working. If the employers in the industry do not take proper interest in the education of their employees, and do not provide the necessary facilities and encouragement to them, the scheme cannot achieve the full measure of success that we hope and believe it will ultimately achieve.

The fact that the number of candidates for examination has gone up from 108 to 162 in the year is certainly encouraging; and it has to be borne in mind, of course, that candidates will not come up for examination except after a period of years of teaching and study. That is the great difference between the present scheme and the old—that this provides for a course of teaching and study, which is a considerable test of the earnestness and determination, as well as of the ability, of the students. It is not merely a swatting-up of one subject for a sufficient time to enable the candidate to pass an examination in that one subject; it is the taking of a complete course of training, and then examination in the main subjects. The Committee, in their Report, have again emphasized the importance—to which I have already referred—of the employers providing sufficient facilities for their employees to take the course of study—facilities which, as it is pointed out, may take the form of time allowances and payment of travelling expenses or of class fees. As mentioned in the Report, we had a very interesting conference with the teachers last year, and we have had another this year, which proved of the greatest interest, and will, I think, be of real value in getting the best work out of the students and out of the teachers.

The Committee do not regard the scheme as in any way a cast-iron scheme, but as one which will no doubt have to be modified in accordance with experience. We do not imagine that the scheme is perfect; we know it is not. We are ready at all times to effect such necessary adjustments as will make for the thorough efficiency of the scheme, for its fitness for its purpose. We are doing all we can to make it easy for students to take the examinations, without lowering the standard of efficiency that is called for in the granting of Certificates and Diplomas. We shall, of course, have to tighten up as time goes on, so that all students will have exactly complied with every condition laid down; but where students have in the past given evidence of their desire for study, and have obtained certificates in other directions, we are giving the fullest possible consideration, in order to encourage such men to continue their education.

I have also, on behalf of the Committee, to express their thanks—I have already done so to the representatives of the Board of Education—to the teachers for the splendid amount of work they put in for their modest fees; to the examiners, who also put in a very large amount of work and thought for no fees at all; and to our good friend, the Organizing Secretary, Mr. Hole, whose devotion to the work of the Institution's Education Scheme is well known to you all. No words of mine could be sufficient to express, on behalf of the Committee, our indebtedness to all those I have mentioned.

I have pleasure in submitting the Report of the Committee to the members of the Institution for acceptance.

* For early years of Course only.

Discussion.

The PRESIDENT: The Report of the Education Committee is now open for your discussion, and we shall be glad to have any observations on the matter. I am very glad that Mr. Goodenough has mentioned the work of the examiners, among others. Their work is increasing more and more; and I can assure you, from an intimate knowledge of what they do, that the thanks of this Institution are very much due to them, and that we are fortunate in having such gentlemen to do the work on our behalf. I shall be glad, however, if members who wish to put forward any observations on the Education Scheme would do so now.

Mr. L. TREWBY (North Middlesex Gas Company): It is most unfortunate that some of the results of the examinations held in May are not yet out. Students who should be enrolling this week do not know what to enrol for—whether for the Higher Certificate, or, if they have not gained the old one, whether to enrol for that one again. Another point is brought to my notice: Could not some certificate be given for the practical gasfitter who is unable to take the theoretical part of the examination? There are a large number of men to-day who cannot go any higher in the practical work; but, inasmuch as they have to take the theoretical part in order to obtain the Diploma, they are unable to take any certificate at all for their work.

Mr. GOODENOUGH: I should like to say that the delay referred to is due to one of the Technical Institutes, and we are taking steps which we hope will prevent so much delay in the future. We appreciate the point Mr. Trewby has put, but it is not our fault.

Mr. H. D. MADDEN (Cardiff): In regard to that question, I hope it is no reflection on any of us, but I can assure Mr. Trewby that I did not receive some of the papers until the morning on which I was trying to get away for a holiday; they were rather late. One or two of the Institution papers have been late like that; it is not the fault of the examiners or assessors, but is simply delay on the part of the particular college.

Mr. DAVID VASS (Perth): I should like to mention the training and examination of students in some of the more remote parts of the country, where the distances they would have to travel to the nearest college are so great that they cannot go in for the work. There is also the point of view of the colleges; in one case they say that unless they get a guarantee of 10 students regularly per annum, they cannot undertake forming special classes. There are students who would study at their works and at home, and I think some facilities should be given to them to study for the examinations as external students. They can study the subjects fairly well as individuals, though perhaps not quite so well as if they were members of a proper class; and I think these young men should not be debarred from attaining the same level as those who are situated in the cities. There are only two centres in Scotland—Glasgow and Edinburgh. Glasgow and Edinburgh are far nearer to each other than any of the other big cities are to Glasgow and Edinburgh. You have Aberdeen, Dundee, Inverness, and Perth, all centres from which it is a day's journey to either Glasgow or Edinburgh, and the students cannot get facilities for attending evening classes without becoming half-timers and going to classes for a period to study. In the case of the smaller works we cannot afford to have students who have to spend half their time in classes and half in the works. I think this is a direction in which the scheme might have to be modified a little. I believe some action is being taken, and we are all anxious to learn what it is. In many cases students are asking where they can attend classes, and whether there is anything nearer than Glasgow or Edinburgh.

Mr. GOODENOUGH: In reply to that, I would say that it is impossible for the scheme to include every possible student in every very far out-of-the-way works, unless he is within reasonable distance of a Technical Institute. It is not necessary for him to be able to attend classes in gas supply or gas engineering in order to enter for the examination, because under Section II. of the scheme he can enter as an external student, provided he has taken the ancillary subjects (which are so fundamental to gas engineering or gas supply) at some Technical Institute where those subjects are dealt with—and there are not many places in the United Kingdom which are completely out of touch with Technical Institutes.

The PRESIDENT: You may rest assured that this work is in good hands. The Committee are working constantly, and I generally leave them at work when I leave the Institution's offices. I do not know what they do after I have gone, but they are busy when I go. [Laughter.] If there are no further questions on this Report, I will ask that its adoption be seconded, and will put the resolution to the meeting.

Mr. SAMUEL TAGG, J.P. (Preston): I have much pleasure in seconding the adoption of this Report.

The Report was adopted.

FIFTEENTH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE OF THE INSTITUTION OF GAS ENGINEERS.

EXAMINATION OF PRODUCTS OF COMBUSTION FROM TYPICAL GAS APPLIANCES.—PART I.

Adopted by the Gas Investigation Committee, May 19, 1926.

RESEARCH SUB-COMMITTEE.

Chairman: Emeritus Professor Arthur Smithells, C.M.G., D.Sc., F.R.S., Director of the Salters' Institute.

Representatives of the University of Leeds: Professor J. W. Cobb, C.B.E., B.Sc., F.I.C. (Honorary Secretary), Emeritus Professor J. B. Cohen, Ph.D., D.Sc., F.R.S., Mr. G. R. Thompson, B.Sc.

Representatives of the Institution of Gas Engineers: Messrs. J. Bond, O.B.E., T. Glover, C.B.E., M.Inst.C.E., Thomas Hardie, M.Inst.C.E., H. Pooley, M.Inst.C.E., S. Tagg, M.Inst.C.E., and C. Wood, O.B.E. Mr. C. S. Shapley was co-opted a member of the Research Sub-Committee for the purpose and period of research work at the Leeds Gas-Works.

Research Chemist: James W. Wood, M.Sc. (Tech.), A.I.C., in charge of investigations concerning the use of gas.

Research Assistant: G. B. Howarth, M.Sc., Gas Engineering (Leeds), A.I.C.

Research Chemist: A. Parker, D.Sc., F.I.C., M.I.Chem.E., in charge of investigations relating to the carbonization of coal.

Research Assistants: H. Kerr, A.I.C., Diploma Fuel and Metallurgy (Leeds), and A. C. Monkhouse, Ph.D. (Leeds), B.Sc., A.I.C.

GENERAL INTRODUCTION TO THE REPORTS OF THE GAS RESEARCH SUB-COMMITTEE, 1926.

The constitution of the Gas Research Sub-Committee has been strengthened during the year by the appointment of Mr. T. Hardie, but has otherwise remained the same, and the staff has remained unaltered.

After careful consideration, the Gas Investigation Committee approved a programme of research work which has been followed during the year. In the first place it was believed to be desirable that the investigation of thermal efficiency obtainable from the combustion of different grades of gas in the appliances commonly used should be supplemented by a very careful examination of the nature of the products of combustion from such appliances, and particularly the investigation and determination of such products of incomplete combustion as carbon monoxide, when they were produced in quantities however small. This investigation had the object of placing before the industry data upon a subject concerning which it is easily possible to make mistaken statements in good faith, and was intended to ensure that the gas industry should be, according to its desire, as completely informed as possible on the hygienic and thermal position occupied by gas-burning appliances.

It will be readily understood that the quantities, for example of carbon monoxide, which have to be dealt with are usually so small that it is necessary to take exceptional precautions for their accurate estimation and to subject any selected method to a most rigorous examination. The Government Chemist, Sir Robert Robertson, and Dr. H. Hartley, of Messrs. Radiation, Ltd., who had both given previous study to the subject, were kind enough to allow themselves to be consulted, and we acknowledge gratefully the assistance they have rendered. Having carefully reviewed the work previously done, Mr. James W. Wood, Research Chemist in immediate charge of this branch of the work, assisted by Mr. G. B. Howarth, proceeded to work out in full detail a form of the iodine pentoxide method suitable for the purpose in hand. Much patience, skill, and resource have had to be exercised, and the Committee would like to record its appreciation. At the same time this opportunity is taken of thanking the Leeds Gas Department and the Manager, Mr. C. S. Shapley, for the facilities which they have continued to extend in a laboratory placed at the disposal of the Committee at the Meadow Lane Gas-Works.

The working out of methods of estimation, which has necessarily occupied considerable time, is being followed by an examination of appliances, starting with the gas fire; and it is intended to extend the work to other appliances in common use.

Another field of work on which the Committee has entered after careful deliberation is a complete and systematic examination of the influence which various factors exert in determining the results of carbonization—factors which in most cases are known to be operative, but concerning which *quantitative* knowledge is not forthcoming. It is the opinion of the Committee that such data must be acquired if proper progress is to be made in the desired development of carbonization processes for the production of the maximum quantity and optimum quality of gas, tar, and coke. For this purpose a special modification of the horizontal retort unit of the Corbet-Woodall Experimental Plant was made with a gas-tight retort of "Cronite" metal, shielded and supported by a fireclay retort and with a new condensing system; the whole arrangement facilitating exact control of temperature (found to be of primary importance), and making accurate measurement possible. Dr. Parker and his assistants, Mr. Kerr and Dr. Monkhouse, are to be congratulated upon the design of this arrangement, and the work they have carried through by its use.

So far, the factor which has been studied has been that of variation in the size of coal carbonized on one coal; but other coals and factors will be studied in turn. Quantities of gas evolved at successive stages of the carbonization with the different sizes of coal have been noted, with the accompanying tar and coke, and special attention has been given to the structure of the resulting cokes. The study of coke structure has now assumed a new importance, and it has been thought advisable to spend some time in preparing samples (according to the method mentioned last year, but now worked out in much more detail) not only of the cokes made in the course of this series of experiments, but of other typical cokes, and of one or two special cokes made during the progress of the work of the Gas Research Fellow by the addition of certain ash constituents, such as oxide of iron and carbonate of soda, to a coal of very low ash content. The Committee would like to record its indebtedness to Dr. Parker and his assistants on this interesting branch of work, the results of which are detailed and illustrated in the text of the Sixteenth Report.

SUMMARY.

It was considered desirable that an examination should be made of the products of combustion discharged from typical gas appliances operated under various conditions. Special attention was to be given to certain constituents, which, though forming only a small proportion of the products of combustion, nevertheless have an important bearing upon the utilization of gas. They include, among other things, carbon monoxide, oxides of sulphur, and oxides of nitrogen.

For the determination of carbon monoxide it was thought that some modification of the well-known iodine pentoxide process would best meet our requirements. Before the examination of the products of combustion could be usefully taken in hand, it was, however, neces-

sary to show that the proposed method was capable of the accuracy requisite for the investigations. Much of the experimental difficulty arises from the fact that the amounts of carbon monoxide are often small and that the products of combustion are greatly diluted with air in the case of the effluent gases from domestic appliances.

This report, which is devoted to the development and critical examination of the iodine pentoxide process for the determination of carbon monoxide, may therefore be regarded as preliminary to the main investigation.

Full details are given of the method finally adopted; and it is believed that, if the necessary precautions are observed, an accuracy of one or two parts per million can be realized in the determination of carbon monoxide in the products of combustion, provided the amount of carbon monoxide is small (say, less than 50 parts per million). Larger amounts can be determined with an accuracy of ± 2 p.ct. of the carbon monoxide present.

AERATION OF HIGH-PRESSURE LIGHTING BURNER.

In order to complete the aeration investigation of the Thirteenth Report, a limited number of tests were made upon a 1000 C.P. lamp, as worked on the high-pressure gas supply in Leeds.

The maximum air-gas ratio attained at 68 in. pressure* was 4·58 with the air regulator fully open. The best illuminating power with the quality of gas used was attained by cutting-down the primary aeration to 3·48, the theoretical air requirement of this gas being 3·91 c.ft. of air per c.ft. of gas.

DETAILED ACCOUNT OF INVESTIGATIONS.

Research Chemist.—JAMES W. WOOD.

Research Assistant.—GILBERT B. HOWARTH.

INTRODUCTION.

The work described in this report was directed towards an examination of the products of combustion from typical gas appliances, such as gas rings, cookers, gas fires, lighting burners (including by-passes) and geysers. The investigation was directed mainly to questions of the completeness of combustion of the gas by appliances in common use, and to hygienic problems connected with the employment of gas. Changes in the kind of gas used and in the degree of aeration, and such variations in the mode of operation as must inevitably occur in practice, may influence results to a marked degree. It is therefore necessary to collect data for a considerable number and variety of appliances, operated under various conditions, before any general statement can be made with confidence.

The main constituents of the products of combustion are, of course, carbon dioxide, water vapour, nitrogen, and excess air. The present investigation, however, is little concerned with these, but rather with the so-called "minor" constituents of the products of combustion. At the outset it must be emphasized that we are dealing with substances which may form only a small percentage of the true products of combustion, and that the technical difficulties of their estimation are increased by the free ventilation and great dilution of these products of combustion with excess air, which usually takes place with domestic gas appliances. In consequence the quantities concerned are usually too minute to be determined by ordinary methods of gas analysis, but this does not mean that they are therefore unimportant.

The products of combustion from a gas appliance form a very complex mixture. In devising a method for the determination of any one constituent, therefore, due regard must be paid to the possible disturbing effects of any of the other constituents. The irregularities caused in carbon monoxide determinations by the presence of oxides of sulphur or oxides of nitrogen furnish an illustration.

In products of combustion the presence of the following may be expected:

(1) The usual impurities in the air used for combustion and dilution of the products of combustion (especially carbon dioxide, carbon monoxide, oxides of nitrogen, oxides of sulphur, ammonia, and hydrocarbon vapours from motor car exhausts or the use of raw coal).

(2) Traces of the unaltered constituents of town gas (which might find their way into the products of combustion either as the result of leakages or by diffusion from the flames).

(3) Carbon dioxide, carbon monoxide, and water vapour, resulting from the combustion of the gas, together with oxides of sulphur, oxides of nitrogen, hydrocarbons, and partially-oxidized bodies such as aldehydes.

The principal methods of investigation which have proved useful in the determination of small quantities of substances when mixed with large volumes of other gases require some consideration.

PHYSICAL METHODS.

By the use of extreme cold or by liquefaction and subsequent fractionation of large volumes of products of combustion, the minor constituents might be so far concentrated as to permit investigation by the usual methods of analysis. The method is laborious, but has already been applied to the examination of air; to coal gas for the determination of the detailed composition of the "hydrocarbons"; and to the determination of unburned fuel in the exhaust gases from motor cars.

We have not had facilities for experimental work on these lines, and moreover it seemed that chemical tests would be more suitable for the work in hand, and these were therefore undertaken.

CHEMICAL METHODS.

(*a*) *Determination of total unburned carbon and hydrogen in products of combustion.*

If it is intended to examine the completeness of combustion of coal gas, a method can be devised which in principle is simple. Suitable volumes of the products of combustion are drawn through tubes containing potash and a drying agent, so that carbon dioxide (and presumably oxides of sulphur and nitrogen) and water vapour are removed. The combustion of the residue is then completed over copper oxide, and the additional carbon dioxide and water vapour are determined. This will indicate the *total* unburned carbon and hydrogen respectively in the residual products of combustion, but will furnish no clue as to the forms in which they are present.

As these unburned constituents may be present in the products of combustion at the sampling point to the extent of only a few parts per million, the application of the test presents considerable difficulties. After due consideration it was decided not to adopt this as our normal scheme for the examination of products of combustion, although the method may be of great value in certain cases.

(*b*) *Determination of carbon monoxide in products of combustion.*

There are reasons for believing that carbon monoxide may be the principal form in which unburned carbon occurs in products of combustion. We therefore directed our attention to the determination of carbon monoxide, regarding it mainly as an index of incompleteness of combustion. In view of statements which have been made from time to time concerning the production of carbon monoxide by gas appliances, it is clearly advisable that the gas industry should have reliable information as to the production of this gas under both normal and abnormal conditions of use.

For the determination of carbon monoxide, it seemed that the well-known iodine pentoxide process would best meet our requirements. The process has been greatly improved since it was first introduced by Nicloux and Gautier, and successive workers have increased its accuracy or adapted it to the requirements of special industries. Among these may be mentioned J. Ivon Graham, F. S. Sinnatt, and the workers of the American Bureau of Mines. Mr. James W. Wood, the Research Chemist, had already some experience in the use of iodine pentoxide for the determination of carbon monoxide where an accuracy of one or two parts in ten thousand was sufficient, but from information in our possession it was evident that a method capable of an accuracy of one or two parts of carbon monoxide *per million* of products of combustion was essential before tests upon gas appliances could be usefully undertaken.

The Government Chemist, Sir Robert Robertson, had

* C.V. of gas, 472 B.Th.U. Sp. gr., 0·52. Consumption at 68 in. pressure, 18 c.ft. per hour.

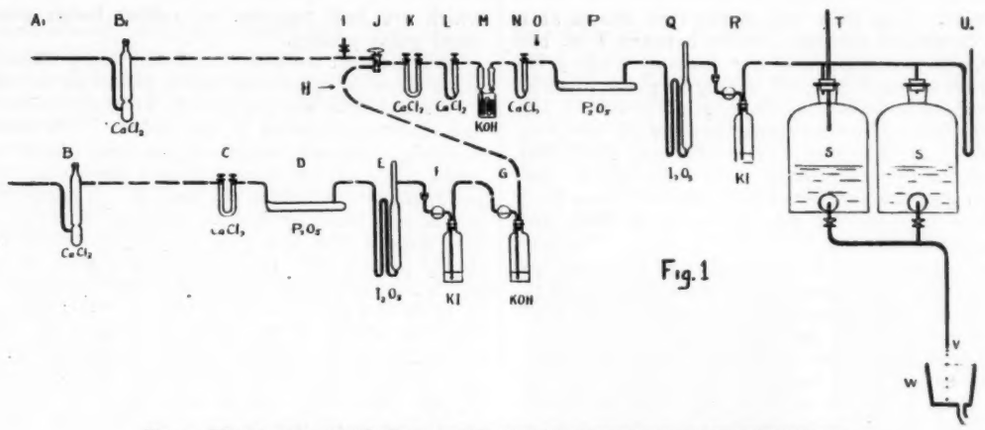


Fig. 1

Fig. 1.—TRAIN OF APPARATUS FOR CARBON MONOXIDE DETERMINATIONS.

been engaged upon investigations involving the exact determination of small amounts of carbon monoxide, and through the kindness of Dr. Lander, of the Fuel Research Board, we were placed in communication with the Department. Sir Robert Robertson immediately furnished us with a detailed description of the apparatus and method he was using. By indicating a suitable train of apparatus (the general features of which we have adopted) and calling attention to a number of sources of error and the means of avoiding them, this communication undoubtedly saved much preliminary work. It could not, however, free us from the obligation of subjecting the method to searching experimental enquiry, in order to satisfy ourselves that the necessary degree of accuracy for our purpose was being attained.

A large portion of this report is therefore devoted to the critical examination and development of the iodine pentoxide process for the exact determination of carbon monoxide; and it is believed that in favourable circumstances an accuracy of one or two parts per million can be realized, provided the concentration of carbon monoxide is less than 50 parts per million in the products of combustion as drawn into the experimental apparatus.

Oxides of sulphur and oxides of nitrogen in the products of combustion have so far only been investigated with respect to their possible disturbing effects upon the carbon monoxide determination.

Two series of tests have been conducted on the products of combustion from gas fires, but the investigation is not yet complete.

Owing to the change in the character of our investigations, some time was spent in acquiring, calibrating, and fitting-up the necessary chemical apparatus and adapting our laboratory to its new work. These special tests cannot very well be carried out in a general laboratory in which other work is being conducted, and the use of a room such as that placed at our disposal at the Meadow Lane Gas-Works, and devoted exclusively to the investigation, has contributed in no small measure to its success. For the continued use of this room and other facilities at the Meadow Lane Works our thanks are due to the City of Leeds Gas Department and to Mr. C. S. Shapley, its Engineer and General Manager.

Principle of the Iodine Pentoxide Test for Carbon Monoxide.

Carbon monoxide can be quantitatively oxidized by iodine pentoxide at a comparatively low temperature (120° C.), liberating iodine and forming carbon dioxide. Either of these, therefore, may be used for the estimation of carbon monoxide, but the determination of the iodine appears to be capable of the greater precision and is in some respects more convenient. The reaction is:

$$5CO + I_2O_5 = 5CO_2 + I_2$$

The method of determining carbon monoxide consists in passing a known volume of products of combustion over heated iodine pentoxide, and determining the amount of iodine liberated. It is necessary also to know the amount of carbon dioxide in the products of combustion, the carbon content of the gas being burned, and the consumption of gas, in order to calculate the rate of carbon monoxide production for any gas appliance.

The apparatus and method about to be described, and the precautions to be observed, are somewhat elaborate, because the carbon monoxide may be present to the extent of only a few parts per million in the products of combustion collected from gas appliances.

Apparatus for Iodine Pentoxide Test.

The general scheme of the train of apparatus for determining carbon monoxide is indicated in fig. 1, details of some of the more important parts being shown in fig. 2 and fig. 3. The products of combustion to be examined

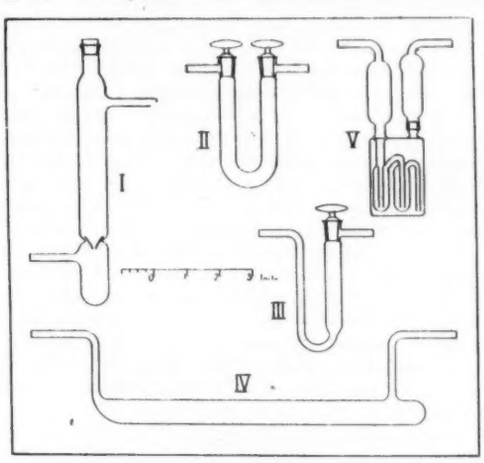


Fig. 2.—Details of Apparatus.

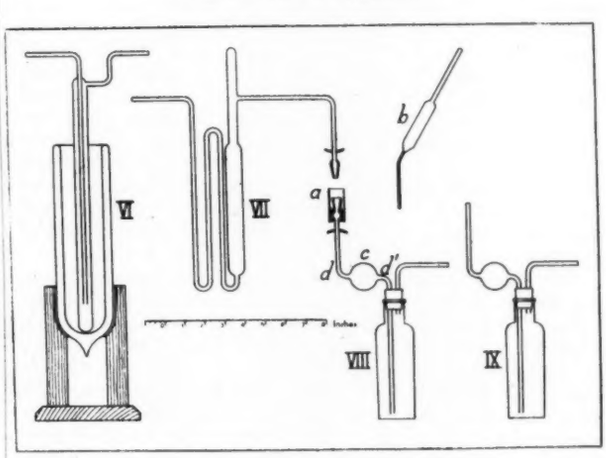


Fig. 3.—Details of Apparatus.

enter the apparatus by the sampling tube A1. The preliminary calcium chloride dryer B1 is placed as close to the sampling point as circumstances will allow. Its object is to prevent water-logging (due to condensation of water vapour from the products of combustion) and absorption of carbon dioxide in the tubes leading to the testing apparatus, which will usually be some distance from the

sampling point. This tube was of the type shown at I, fig. 2, and contained calcium chloride between ⅛ in. and ¼ in. mesh. Between B1 and the two-way cock J the sample travels through suitably arranged glass tubes of 4 mm. bore, fused into a continuous length. Near J, a side arm I is inserted whereby the space between the sampling point and the cock J can be swept clear and filled with current products of combustion when starting a test. Further drying of the products of combustion takes place in the **U**-tube K (type II, fig. 2), which is filled with calcium chloride between $\frac{1}{16}$ in. and ⅛ in. mesh. A single-limb calcium chloride tube L (type III, fig. 2) is weighed from time to time as a check upon the condition of K. Owing to the removal of most of the water by B1, both K and L will last for many determinations.

Carbon dioxide is removed quantitatively at this stage, either potash or soda-lime being used. Potash bulbs of type V, fig. 2, have proved very efficient. They are easily wiped, will stand firmly on the balance pan, weigh about 65 grammes when charged with 15 c.c. of potash solutions (sp.gr. 1·44)*, throw about 5 in. back-pressure, and can be conveniently worked at a rate of 1 to 1·5 litres per hour. For many of our tests the small calcium chloride tube attached to the potash bulbs has proved inadequate, and a supplementary guard-tube N, similar to L, has been used and separately weighed. Depending upon the age and condition of the calcium chloride in the potash bulb guard-tube, this supplementary guard-tube has shown an increase in weight of 0·05 to 0·15 mg. per litre of products of combustion passed through it, entailing an appreciable correction to the weight of CO_2 collected in the case of low concentrations of CO_2 (say, less than 0·2 p.ct.). Alternatively, soda-lime may be used in tubes of type II, fig 2, for the removal of CO_2. The back pressure of such tubes is small, and as there is neither bubbling nor splashing they can be used at a much higher rate than potash bulbs. The soda-line is followed by calcium chloride, exactly as in the case of potash. Our experiments have not shown any superiority of either reagent for the removal of CO_2; but, being restricted to a rate of about 1 litre per hour by the resistance of the iodine pentoxide tube, we have generally used potash bulbs of the type indicated. If used (see section on oxides of nitrogen), a condensing tube of type VI, fig. 3, immersed in liquid air may be inserted at O, in which case the phosphorus pentoxide tube P may be dispensed with. The phosphorus pentoxide tube P is used for final drying of the residual products of combustion before they enter the iodine pentoxide tube, as moisture at this point might be harmful to the reagent.

The iodine pentoxide tube Q (type VII. fig. 3) is of the type and dimensions suggested in the communication from the Government Chemist, and holds 80 grammes of iodine pentoxide. It has, however, been modified in two details. The zig-zag "preheater" on the inlet side has been reduced from seven to three vertical tubes, which should still be sufficient to secure ample preheating of the gases; the top of the iodine pentoxide chamber has been finished as a tee-piece, which simplifies the operations of filling, emptying, and hermetically sealing the tube. No trouble has occurred due to condensation of iodine in the dead-end which protrudes from the furnace and is covered with an asbestos thimble. The preparation of the reagent and method of heating the tube are described later in special sections.

The iodine absorber R and the method of connection to the iodine pentoxide tube are important features of the train. The iodine liberated from the iodine pentoxide must on no account be brought into contact with rubber, by which it would be absorbed, so that the connection is made by a ground-glass joint. For the same reason the joint cannot be lubricated with any of the materials usually employed for glass taps. The joint may be rendered gas-tight by lubrication with distilled water, but after a few hours the film of water evaporates and allows the joint to leak. We therefore built up a small water-lute round the joint, as shown at fig. 3, VIII (*a*). Before the apparatus is disconnected at this joint, the water is removed from the lute by means of a small pipette (*b*), and is thus not allowed to run into the absorber. The apparatus is arranged to exert no pull on the joint, the two parts of which are held together by rubber bands passing over small glass prongs.

At the outset we were faced with the problem of devising a piece of apparatus which would be an efficient absorber of iodine and yet present little obstacle to washing and accurate titration of the iodine. The usual single-bubbling Drechsel bottle fails to meet the first requirement, while several more complex absorbers we have experimented with fail on the second. A suggestive observation was made by Dr. H. Hartley, of Radiation, Ltd., who noticed that if a gas carrying traces of iodine was slowly passed over the surface of a pool of potassium iodide solution, most of the iodine was absorbed. This led us to design the absorber shown at VIII, fig. 3. Practically the whole of the iodine is caught by the pool of potassium iodide solution resting in the bulb (*c*), and the remainder in the almost iodine-free solution in the bottle beyond. Bubbling can be introduced by adjustment of the angles at (*d*) and (*d*¹), but we have not observed any marked improvement in the absorption on so doing. It is clear that the iodine collected in the bulb can be readily washed into the bottle, in which the whole is then titrated. The rubber stopper in the neck of the bottle R allows an interchange of bottles which is sometimes convenient and gives flexibility to the apparatus. As the iodine has all been absorbed at this stage there is no objection to the use of the rubber stopper.

At the extreme right of fig. 1 are the aspirators S, which serve both to draw over and to measure the residual products of combustion. Two aspirators of 10 litres capacity and one of 5 litres capacity are available for each train. A rubber tube descends from each aspirator to secure the necessary suction, and carries a glass jet, selected by trial to be of such a size as will run out the water at a suitable rate when the cock on the aspirator is fully opened. The aspirators are graduated, and volumes greater than 5 litres are read on these graduations. Smaller volumes are determined by collecting the water and measuring it in a cylinder. Fig. 1 shows two 10-litre aspirators connected in parallel and controlled by one water jet, and is the arrangement by which most of our long-period tests, using upwards of 15 litres of products of combustion, have been made. A thermometer T and water gauge U for indicating the suction in the aspirators complete this part of the apparatus.

Before a test is commenced the apparatus is thoroughly swept with air which has been passed over iodine pentoxide and has had the resultant iodine and carbon dioxide removed. This "purified air" is prepared by drawing air from outside the building through the sampling tube A, preliminary calcium chloride dryer B, second calcium chloride **U**-tube C, phosphorus pentoxide tube D, iodine pentoxide tube E, and iodine absorber F, each of these performing functions similar to the corresponding units in the train already described. An additional vessel G containing potash solution is inserted after F to remove traces of iodine and the carbon dioxide produced in E. This purified air is then admitted to the experimental train by means of the cock J. During preparatory sweeping the potash bulbs M and calcium chloride tube N are removed, their places being taken by suitable lengths of glass tubing. The absorber R is also removed and its place is occupied by a spare absorber connected with a short piece of rubber tubing (fig. 3, IX) to the spigot end of the glass joint on one side and the 5-litre aspirator on the other.

As it was intended to make simultaneous tests upon air and products of combustion, the complete train of apparatus described above was fitted-up in duplicate. With four iodine pentoxide tubes available, and with suitable cross-connections, we were able to investigate certain fundamental matters connected with the tests in a way that would not otherwise have been possible. The four iodine pentoxide tubes are simultaneously heated in the same furnace, being brought into a convenient position for this purpose by folding the train on itself at the cock J (fig. 1), and working the purifying train from right to left and the experimental train in the direction shown. For convenience, all connections and side arms have been made of glass tubing of one size (4 mm. bore and 6 mm. external diameter), and black rubber tubing covering glass to glass joints has been used for connecting the apparatus together. This is more flexible and more easily attached

* 1 lb. stick potash to 500 c.c. water.

than pressure tubing, and clings well to the glass, but requires frequent inspection and renewal. The various U-tubes are suspended from two iron rods running the length of the bench, and the bottles are supported at suitable heights on wood blocks.

PREPARATION OF IODINE PENTOXIDE.

As a reagent for the determination of small amounts of carbon monoxide, iodine pentoxide prepared by the direct oxidation of iodine with nitric acid is not regarded with favour; it is alleged that the material is not stable; and that it is difficult to free it from traces of oxides of nitrogen, which interfere with the carbon monoxide determination. The material used for our tests was therefore prepared by the method described by Lamb, Bray, and Geldard (J.Am.Chem.Soc., 1920, pp. 1636-48). It consists in the preparation of chloric acid from barium chlorate and sulphuric acid, and oxidation of iodine to iodic acid by means of this chloric acid. The iodic acid is concentrated by evaporation to a syrup and with constant stirring to a pasty mass and eventually to a dry granular powder. It is then heated in an air oven at 150° to 160° C. for three hours, in order to dehydrate the iodic acid and leave iodine pentoxide. As a precaution against enclosures of iodine or undecomposed iodic acid, Lamb, Bray, and Geldard grind the material to pass an 80-mesh sieve. This plan was followed, but is troublesome because the material is very hygroscopic. The final preparation of the material takes place after filling the iodine pentoxide tubes described above. This is done by heating the newly-filled tubes to 220° C. and passing pure dry air through them so long as water is evolved (say, 6 hours). Sweeping is maintained and the temperature is dropped for several successive days until 120° C. is reached. The sweeping is continued until consistent blanks can be obtained as indicated in the section "Iodine Pentoxide Blanks at 120° C." For filling our four iodine pentoxide tubes we prepared about 400 grammes of the material in one batch, the yield of the finished product being about 85 p.ct. of the theoretical on the iodine used.

According to the communication received from the Government Chemist, it would appear that he employs a gas rate of about 5 litres per hour through the train of apparatus, but we have never been able to attain this figure. The average suction in our aspirators has been 10-in. water-gauge, and in view of the large number of joints in the apparatus we have not cared to exceed this value. As a result, our rate of sampling has not greatly exceeded 1 litre per hour, and the tests have been correspondingly prolonged for the treatment of a given volume of products of combustion. Examination disclosed the fact that the trouble was mainly due to the resistance presented by the finely-ground powder in the iodine pentoxide tubes; but after due consideration it was decided to continue tests with the apparatus as it stood, especially as the smaller gas rate seemed conducive to complete absorption of iodine and carbon dioxide. In any future preparation, however, our aim would be to produce a granular product free from dust and with particles about ½ mm. in diameter.

ELECTRIC FURNACE AND HEATING OF IODINE PENTOXIDE TUBES.

The temperature to which the iodine pentoxide must be heated is not a high one, being only 220° C. for short periods and 120° C. for general working. It was our original intention, therefore, to place the four iodine pentoxide tubes in one gas-heated oil bath, and to secure a uniform temperature by means of the usual mercury thermo-regulator and stirring gear. Great difficulty was experienced in obtaining a suitable oil. Nine samples of high flash-point and high boiling-point oils recommended for the purpose were tried, but at these temperatures all gave off hydrocarbon vapours due either to cracking or to distillation. The personal inconvenience thus entailed was a small matter compared with the irregularities which we were afterwards able to demonstrate would result from the presence of small amounts of these hydrocarbon vapours in the air of the laboratory. A gas-heated air-bath was proposed, but it seemed advisable, if at all practicable, to exclude from the laboratory all gas-using appliances other than that being tested.

To meet our requirements a 200-volt electric supply was specially installed, and an electric furnace and a control panel (figs. 4, 5, 6, and 7) to work directly on this supply were designed and constructed in the laboratory. The basis of the furnace was the brazed copper cylinder originally intended for the oil bath (11 in. long by 5 in. diameter). The lid carries a framework for the support and proper spacing of four iodine pentoxide tubes. It also supports four heating elements made from 24 S.W.G. nichrome wire. These are wound on glass tubes as insulators and are connected in series, presenting a total resistance of 150 ohms. The control panel consists of a set of similarly

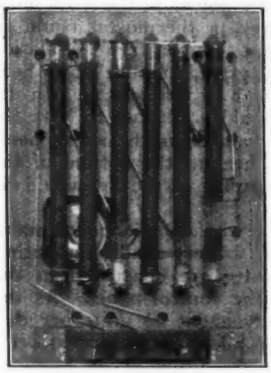


Fig. 5.

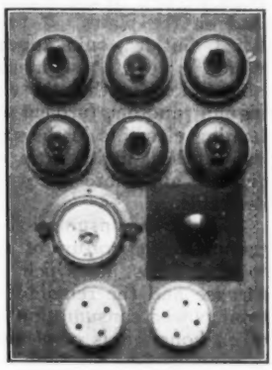


Fig. 4.

Back and Front of Control Panel.

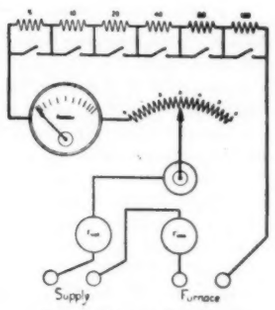


Fig. 6.—Circuit Diagram.

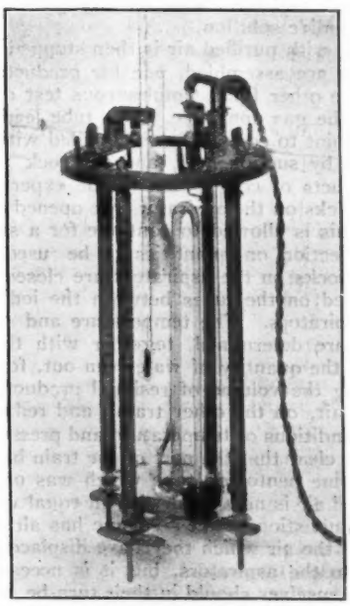


Fig. 7.—Heaters for Electric Furnace.

wound resistances starting with 5 ohms and each having a resistance double that of the preceding one. By suitable operation of the switches all intermediate resistances can be built up in multiples of 5 ohms, while a 6-ohm slide resistance in series provides fine adjustment.

The body of the furnace was wrapped with a ⅜-in. layer of asbestos cord, sufficient to protect it from sudden fluctuations in temperature due to draughts, &c., but still permitting rapid adjustment by means of the control

panel. At a later stage, when it had been decided to work at one temperature only, the furnace was further surrounded by a packing of Kieselguhr 2 in. thick. This did not reduce the thermal losses by more than 25 p.ct., but improved the uniformity of temperature distribution in the furnace, and, by adding to the total thermal capacity of the apparatus, smoothed-out temperature fluctuations. Given a steady voltage, this furnace maintains a constant temperature difference above that of the room. There are, however, unmistakable fluctuations in current and in temperature due to the demands for power in the workshops and on the plant. If necessary, a thermostat could be fitted, but it would appear that temperature regulation within ± 10° C. is sufficiently good, and we have been able to keep within these limits by hand control. In designing another furnace we should prefer not to have the heating elements in the same chamber as the iodine pentoxide tubes, and a little more heat at the bottom of the furnace and more adequate lagging of the lid would be desirable.

The power consumption of the whole appliance for maintaining a temperature of 120° C. is very small, amounting to 105 watts, of which 42 watts are consumed in the furnace and the remainder in the control panel. As the total power consumption is only about 2½ units per day of 24 hours, it is convenient to allow the furnace to run continuously at a steady temperature, unless not required for several days, when it may be switched off.

Method of Conducting Carbon Monoxide Determination.

It is assumed that the apparatus has been fitted up as already described and that the furnace has been at its working temperature (120° C.) for several hours. Air is drawn through both purifying trains by means of spare aspirators, and allowed to sweep the corresponding experimental trains free from any accumulated iodine or other undesirable substances. We regard it as important that this should be done at the temperature and at about the rate that will prevail during the carbon monoxide determination, and it must be continued for as long as experience shows to be necessary. In the case of our apparatus and conditions of working, a period not less than 1½ hours is satisfactory. During this time the necessary calcium chloride tubes and potash bulbs are prepared and weighed, and the iodine absorbers are charged with potassium iodide solution.

Sweeping with purified air is then stopped and the complete trains are assembled, one for products of combustion and the other for a simultaneous test on the air approaching the gas appliance. The tube leading from the sampling point to cock J (fig. 1) is filled with products of combustion by suction at I, and the cock J is turned to admit products of combustion to the experimental train, when the cocks on the aspirators are opened and sampling begins. This is allowed to continue for a suitable period (see next section on quantities to be used, &c.), after which the cocks on the aspirators are closed and a pinch clip is placed on the tubes between the iodine absorbers and the aspirators. The temperature and suction in the aspirators are determined, together with the barometric height and the quantity of water run out, for the purpose of obtaining the volume of residual products of combustion (or of air, on the other train), and reducing them to standard conditions of temperature and pressure.

It will be clear that the part of the train between cock J and the iodine pentoxide tube which was originally filled with purified air is now filled with an equal volume of products of combustion. Their volume has already been obtained from the air which they have displaced and pushed forward into the aspirators, but it is necessary that the products themselves should in their turn be swept forward so as to react with the iodine pentoxide. The cock J is therefore turned to supply purified air for sweeping forward the products of combustion and iodine standing in the train; the pinch clips are removed, and sweeping is allowed to take place by means of either the regular aspirators or spare 5-litre aspirators. It is not necessary that the volume of sweeping air should be accurately known, but our experience shows that at least 2 hours' sweeping is necessary. After sweeping has been in progress for about half-an-hour, the aspirators may be clipped off and the potash bulbs and calcium chloride tubes may be transferred to the balance case and allowed to stand before weighing. Their places are filled with plain glass tubes, and sweeping is resumed.

During the test the necessary meter readings will have been made for obtaining the gas consumption of the appliance, and a sample should be collected for the purpose of making an analysis and determining the carbon content of the gas being used. When sweeping is complete the potassium iodide absorbers are removed, the iodine is washed into the bottles, and the contents are titrated with N/500 sodium thiosulphate solution. Two potassium iodide "blanks" which have been standing beside the absorbers throughout the test are also titrated. If another test does not follow immediately, the spigot ends of the iodine pentoxide tubes are closed with caps, lest water vapour or liquid should find its way into the iodine pentoxide tubes. The data obtained are then treated as described in the section "Calculation of Results."

Quantities to be Employed.

An outline of the method of making a test has now been given. Difficulty arises, however, in making recommendations as to the details of procedure. Much will depend upon the nature of individual tests and the degree of accuracy required. It may often prove necessary to make a preliminary trial in order to determine the experimental conditions which will ensure the greatest accuracy in the prevailing circumstances. The following suggestions respecting the main factors which require consideration may be of service.

1. *CO_2 Produced per C.Ft. of Gas.*—If this is determined by combustion over copper oxide as described in our Fourth, Eleventh, and Thirteenth Reports, an accuracy of ± 1 p.ct. is attainable with ease.

2. *Weight of CO_2 Collected from Products of Combustion.*—As the result of exposure, handling, wiping, and changes in atmospheric temperature and pressure, soda-lime tubes and potash bulbs are subject to apparent variations in weight. These can be materially reduced by using similar vessels as counterpoises; even so, it is our experience that the irregularities are greater than the errors of a good chemical balance (*i.e.*, one responding consistently to a change in load of 0·1 mg.). The weights of CO_2 absorbed are not to be trusted more closely than ±0·5 mg. and errors of 1 mg. may occasionally be expected. It is therefore advisable to work so that the weight of CO_2 absorbed exceeds 20 to 25 mg. In some cases, notably that of CO_2 in air, circumstances may compel the use of smaller quantities.

3. *Amount of Iodine Collected.*—If the total uncertainty in the production and determination of the iodine is about ± 0·2 c.c., a titration of 10 c.c. will allow an accuracy of ± 2 p.ct., which is ample for most purposes. The accuracy may be increased by collecting larger quantities of iodine, but with the type of absorber we have described it is not advisable to collect more than will require 20 to 25 c.c. of N/500 sodium thiosulphate for its titration. If this amount is exceeded there may be difficulty in making the titration in accordance with our standardized procedure, and also risk of iodine escaping absorption. Circumstances may sometimes compel the use of titrations of only 1 or 2 c.c., but larger volumes are to be preferred if attainable.

4. *Duration of Test or Volume of Products to be Used.*—Before making a test it is necessary to maintain the iodine pentoxide tubes at a steady temperature and to sweep them with purified air for not less than 1½ hours. It is also necessary to sweep for at least 2 hours after cutting-off the products of combustion. Hitherto we have not attempted these delicate titrations by artificial light, so that the fading of daylight will fix the hour at which the test must cease. The maximum time available for a test started and finished on the same day is therefore from 4 to 6 hours, which, at the rate of sampling we have been able to attain, means dealing with 4 to 6 litres of products of combustion. If this is insufficient, the next most useful step is to use about 16 litres, and to continue the test overnight. Two 10-litre aspirators in parallel will provide enough capacity for a run of 16 hours with safety. Tests of longer duration than 24 hours are not to be recommended, on account of irregularities which may arise in the various "blanks." On account of uncertain variations in the temperature and pressure of the vessels form-

ing the train of apparatus, we do not recommend the use of smaller volumes than two litres of products of combustion with this type of apparatus.

Experimental conditions may arise in which it is impracticable to maintain a gas appliance in a steady state for sufficient time to enable a reliable carbon monoxide determination to be made by direct sampling into the train of apparatus we have described. Occasionally, also, it may be necessary to investigate transient conditions such as those which obtain during the first few minutes after a gas appliance is lighted, or when a cold kettle is placed over a burner. To meet such conditions, we devised the plan of drawing a sample of products of combustion at a relatively high rate through weighed soda-lime tubes into a holder. After thorough mixing, a portion of the sample thus collected could be passed slowly through the complete carbon monoxide apparatus in the ordinary way. Great care is, however, necessary in the selection of the holder. For example, a 5 c.ft. test holder, after thorough cleaning, was filled with air containing about 5 parts of carbon monoxide per million; after standing 72 hours, the issuing air showed a "carbon monoxide" content of 40 parts per million. This was doubtless derived from the paint or other preservative used in the holder and its connections, and clearly rendered the holder unsuitable for the purpose intended.

Method of Calculating Results.

There are two main operations in calculating the results of tests—(1) the determination of the proportion of carbon monoxide by volume in any representative sample of products of combustion drawn through the experimental train; (2) the correlation of this quantity with the amount of gas burned, so as to obtain the rate of carbon monoxide production, eliminating the effects of that unavoidable and variable dilution of the products of combustion with excess air, which would render comparison of results impossible. The connecting link is the "dilution factor" (p), which expresses the ratio between the volume of the products of combustion and that of the gas burned.

All volumes should be compared under the same conditions of temperature and pressure, and as a matter of convenience we have used the standard conditions conventional in the gas industry—viz., 60° Fahr. 30-in. barometer, and saturated with water vapour.

Let r = the volume of air supplied per c.ft. of gas burned. (Part of this is used for combustion, the remainder acts as a diluent for the products of combustion.)

p = the combined volume of products of combustion and excess air per c.ft. of gas burned (assuming the water vapour produced by the combustion of hydrogen to be condensed).

Now the products of combustion of 1 c.ft. of typical coal gas or coal-gas water-gas mixture occupy about 1·3 c.ft. less than the sum of the gas and air before combustion (see Fifth Report),

$$\therefore\ r = (p + 0{\cdot}3).$$

Further, let

n = volume of CO_2 produced by complete combustion of 1 c.ft. of the gas used,

m = volume of CO_2 originally present in 1 c.ft. of air used,

c = volume of CO_2 found per c.ft. of products of combustion.

$$\text{Then } c = \frac{n + rm}{p} \text{ and } p = \frac{n + 0{\cdot}3\,m}{c - m} \quad . \quad . \quad . \quad . \quad (1)$$

(*i.*) The value of n usually lies between 0·45 and 0·50, while $0{\cdot}3m$ is generally less than 0·0002 (corresponding with 7 parts of CO_2 per 10,000 of air). Without introducing significant error, therefore, the above formula may be reduced to

$$p = \frac{n}{c - m} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

(*ii.*) This formula is sometimes further reduced to $p = n/c$ With well-ventilated gas appliances, however, the CO_2 in the products of combustion is frequently less than 1·00 p.ct. It is clear, therefore, that a simultaneous determination of the CO_2 in the air approaching the appliance is essential, for this will normally have a value of 0·04 p.ct. upwards, involving a correction to p of at least 4 p.ct., and becoming increasingly important as c diminishes or m becomes larger.

(*iii.*) Strictly speaking, the value of p should be determined on the basis of a balance between the carbon in the products of combustion and that in the gas consumed. When n is determined by a combustion over copper oxide, the CO_2 is a measure of the *total* carbon in the gas. On the other hand $(c - m)$ does not represent the total carbon, derived from the gas, appearing in the products of combustion, for some carbon is present as carbon monoxide. The values of c and m should, therefore, be increased by the corresponding volumes of carbon monoxide found (assuming that carbon does not escape unburned in any other form). Whether correction on this account is necessary or not must be decided for individual cases, but we have met with examples in our own tests where the correction to p was more than 10 p.ct.

(*iv.*) Except in special cases when dealing with restricted air supplies, p is sensibly equal to r and may be interpreted either as the volume of products of combustion or the amount of ventilation effected. If p is greater than 30, the difference is less than 1 p.ct.

The amount of carbon dioxide in the products of combustion is determined gravimetrically, and it is necessary to calculate the corresponding volumetric quantities.

Let V = the volume in litres of the residual products of combustion collected in the aspirator, after removal of CO_2 and correction to 60° Fahr. and 30 in. wet.

v = volume in litres of CO_2 absorbed, calculated for 60° Fahr. and 30 in. wet.

w = weight in grammes of CO_2 absorbed.

Assuming that 44·0 grammes CO_2 occupy 22·4 litres at 0° C. and 760 mm. mercury pressure

Vol. of CO_2 at 0° C. and 760 mm.

$$= \frac{w}{44{\cdot}0} \times 22{\cdot}4 = 0{\cdot}509w \text{ litres.}$$

But 1 vol. of any gas at 0° C. and 760 mm. becomes 1·073 volumes at 60° Fahr. and 30 in. wet.

Therefore $v = 1{\cdot}073 \times 0{\cdot}509w = 0{\cdot}546w$ litres.

$$\text{Therefore } c = \frac{v}{V + v} = \frac{0{\cdot}546w}{V + 0{\cdot}546w} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

A precisely similar calculation suffices for the determination of m.

Carbon monoxide liberates iodine from iodine pentoxide according to the equation

$$5CO + I_2O_5 = 5CO_2 + I_2$$

and this iodine is titrated with N/500 sodium thiosulphate solution; therefore 1 c.c. N/500 sodium thiosulphate solution

= 0·1120 c.c. CO at 0° C. and 760 mm.
= 0·1201 c.c. CO at 60° Fahr. and 30 in. wet.

If x = volume in c.c. of N/500 sodium thiosulphate solution used in titrating the liberated iodine, the concentration q of CO in the products of combustion at the point of sampling (in parts per million) is given by:—

$$q = \frac{120{\cdot}1x}{V + v} \text{ parts per million} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The concentration q^1 of carbon monoxide in the air approaching the apparatus is calculated in a similar manner. It is understood that the titration figures used in the above calculations are the net figures after deducting the potassium iodide and iodine pentoxide "blanks" (*q.v.*).

The value q obtained from equation (4) is the concentration of carbon monoxide actually present (in parts per million) in the products of combustion at the sampling point, and is not concerned with the manner in which that concentration may have been brought about. In considering the carbon monoxide *produced* by a gas appliance, however, it is reasonable to deduct any carbon monoxide present in the air supplied to it*, and we therefore have

$(q - q^1)$ = concentration of carbon monoxide in the products of combustion (as sampled) due to the gas appliance.

The production of carbon monoxide per c.ft. of gas burned is clearly given by the product $p\ (q - q^1)$ and the corresponding thermal loss can be readily calculated.

If Q = gas rate in c.ft. per hour,

then the total output of carbon monoxide in c.ft. per hour $= pQ\ (q - q^1)$ . . . . . (5)

* This assumes that the greater part of the air acts merely as a diluent for the products of combustion, and that only a small portion passes through a zone of flame or other heated region where the carbon monoxide in the air might be burned to CO_2.

This latter figure is very important in the case of appliances which discharge the whole of their products of combustion into the air of the room in which they are used, and enables one to decide upon the amount of ventilation necessary to reduce the concentration of carbon monoxide below a specified limit.

INVESTIGATION OF IODINE PENTOXIDE PROCESS FOR DETERMINATION OF CARBON MONOXIDE.

If experimental conditions are suitably arranged, iodine pentoxide is a valuable reagent, for it renders the determination of carbon monoxide possible in the presence of certain other oxidizable gases, which may occur in the products of combustion from gas appliances. The experimental work which follows is directed towards ascertaining what those conditions are. The carbon monoxide is determined from the amount of iodine liberated, and the exact determination of very small amounts of iodine is required. It is, moreover, necessary to satisfy oneself that the whole of the liberated iodine is collected, and that all gains or losses of iodine due to causes other than the action of carbon monoxide upon iodine pentoxide are eliminated or taken into account, so that the carbon monoxide may be correctly evaluated.

PREPARATION, PROPERTIES, AND USE OF N/500 SOLUTIONS.

The iodine liberated is determined by means of N/500 sodium thiosulphate solution. It was found at an early stage in the investigations that, when working with such highly-diluted solutions, the whole of the conditions attendant upon titrations had to be standardized if consistent results were to be obtained; and the procedure which we have found convenient is described below.

The conditions which we found it necessary to standardize were:

1. The type and dimensions of the titration vessel.
2. The final volume of the liquid at completion of the titration.
3. The amount of potassium iodide present.
4. The amount of indicator.
5. The condition to be taken as the "end point" of the titration.

The titrations are frequently very small, or involve the determination of small differences; and we have found it necessary to employ accurately calibrated burettes and to read them with the help of a reading microscope clipped to the stem of the burette. It was desirable that all titrations should be conducted in the bottles used for the iodine absorbers (R, fig. 1), and conditions were to some extent adjusted to permit of this being done. The bottles were nominally of 6 oz. capacity, holding 200 c.c. to the shoulder, and having an over-all height of 6 in. and an external diameter of 1⅞ in. In determining the end-points of titrations, much importance attaches to the colour and similarity of these bottles; and a sufficient number of water-white "oil-sample" bottles were obtained in one batch for the purpose.

To secure uniformity in the conditions as to end-point, all solutions titrated in these bottles were made up to a bulk of 75 c.c. with distilled water immediately before adding the last c.c. or so of the titration. The titrations were made in good diffused daylight with the bottles standing on a sheet of white paper, and complete discharge of the colour of the indicator was taken as the end-point. 1 c.c. of the indicator was used, and the definition of the end-point will be discussed more fully at a later stage.

The following solutions are required:

1. Starch solution, as indicator.
2. Stock decinormal sodium thiosulphate solution.
3. Stock decinormal iodine solution.
4. Special decinormal sodium thiosulphate solution.
5. N/500 sodium thiosulphate solution.
6. N/500 iodine solution.
7. 10 p.ct. potassium iodide solution.

Starch Solution.

Trials were made with a number of natural starches and prepared "soluble" starches with the object of finding the most sensitive, and determining the minimum amount of iodine necessary to give a perceptible colouration. It is clear that this minimum amount may be a considerable proportion of the total iodine present where circumstances compel the use of titrations so small as 1 or 2 c.c. of N/500 sodium thiosulphate solution. As will appear later, however, conditions can be so arranged that the value of the small but necessary amount of iodine required to react with the indicator need not be known, so long as the indicator is sufficiently sensitive and a definite end-point can be specified. Eventually we adopted the use of a solution of potato starch freshly and quantitatively prepared each day.* For use as an indicator, 1 c.c. of this solution is measured with a pipette and added to the iodine solution undergoing titration when the colour has been reduced to a pale yellow. The filtration is tedious but well worth while, owing to the clearness of the blue colour and freedom from coloured specks in the solution, which with the unfiltered starch seem to persist long after the colour has been discharged from the bulk of the solution.

It was confirmed that, in order to secure the greatest sensitivity of the starch, it was necessary to have potassium iodide present (see Treadwell and Hall, Analytical Chem., Vol. II., p. 652; or Mellor, Inorganic Analysis, p. 286). Our own experience would suggest that a suitable amount is that corresponding to 0·1 to 0·25 p.ct. of potassium iodide in the total volume of the finished titration. In dealing with decinormal solutions there will usually be enough potassium iodide present in the N/10 iodine to meet this requirement. (We use 30 grammes of potassium iodide per litre of N/10 iodine solution.) Where N/500 solutions are prepared by simple dilution of the N/10 solutions, the addition of 1 c.c. of 10 p.ct. potassium iodide solution is desirable in each titration to meet the above requirement.

Decinormal Solutions Required.

The first requirements are stock decinormal solutions of sodium thiosulphate and iodine. It is not necessary that either of these should be prepared with great precision, as they are subsequently standardized; but both should be stored in well-stoppered bottles in a cool place and should not be unduly exposed to light.

The key solution to the whole series of titrations is a freshly-prepared decinormal solution of sodium thiosulphate made up when required to an exactly known strength from pure anhydrous sodium thiosulphate, in order to avoid uncertainty as to the water content of "pure" sodium thiosulphate crystals. Pure sodium thiosulphate crystals are dehydrated in a vacuum desiccator over sulphuric acid and afterwards dried to constant weight in an air-oven at 80° C. Several successive quantities of 25 c.c. of the stock iodine solution are titrated with this standard sodium thiosulphate solution and with the stock sodium thiosulphate solution in turn, so that the strength of the latter is accurately determined.

By testing the stock sodium thiosulphate solution at intervals in this way, we have been able to confirm the opinion of others—that the decinormal sodium thiosulphate solution is very stable, notwithstanding the fact that our stock bottle was frequently opened for the preparation of N/500 solutions. The average deterioration of our stock solution over the whole period of the tests was barely 1 p.ct. per annum.

N/500 Solutions.

The N/500 sodium thiosulphate solution is prepared by taking 10 c.c. of the N/10 stock solution and diluting it to 500 c.c. with distilled water. There was some question as to the reliability of the very dilute solution prepared in this way. Dissolved CO_2 and oxygen in the distilled water may easily attain concentrations which are not negligible compared with N/500 strength; while boiling, to remove these, may easily result in the solution of alkali to an equally unsatisfactory amount. The question of the disturbance of the end-point of the reaction by such dilution arises; traces of impurity in the distilled water will also have an effect.

On the assumption that it was unlikely that impurities in the distilled water would affect both iodine and sodium thiosulphate in the same way, the following tests were

* 1 gramme of starch mixed into a cream with 5 to 10 c.c. of distilled water is poured while stirring into 200 c.c. of boiling water, and allowed to boil for 1 minute. It is then cooled under a tap and filtered.

made. Decinormal iodine and sodium thiosulphate solutions were accurately matched. N/500 solutions were prepared from these by simple dilution. The N/500 solutions were then compared by titrating one against the other. They differed by an amount rather greater than known experimental error; but as the difference was less than 1 p.ct., the validity of this method of preparing N/500 sodium thiosulphate solution was accepted.

We also took suitable weighed quantities of the N/10 iodine solution and titrated them with the N/10 and N/500 sodium thiosulphate solutions respectively, and deduced the same strength for the iodine solution whichever thiosulphate was used.

It is our experience that N/500 sodium thiosulphate solution does not keep so well as the N/10 solution, and for exact work we should not care to use without standardization a solution more than three days old. The method of testing has been to take the residue of an N/500 sodium thiosulphate solution, and compare it with an N/500 solution freshly prepared by dilution of N/10 stock, titrating each against equal volumes (25 c.c.) of the same iodine solution, also of approximately N/500 strength. The following are typical results:

Solution Number.	Days Elapsed Since Preparation.	Deterioration P.Ct.	Deterioration P.Ct. per Day.
27	12	4·0	0·33
37	10	4·1	0·41
40	11	5·9	0 54
44	17	5·0	0·29
..	17	6·7	0·39
		Mean . .	0·40

The deterioration is naturally subject to variation with the character of the water used for dilution, the frequency with which the flask has been opened during use, and the conditions of storage in the interim. There is also reason to suppose that dissolved CO_2 strengthens the solution at first by the production of sulphite (which consumes more iodine than the thiosulphate), and that oxidation and decomposition are masked by this at first; it is thus possible to find the strength of the solution unaltered at the end of the first one or two days.

Potassium Iodide "Blanks."

Potassium iodide solution is used for absorbing the iodine liberated from the iodine pentoxide, and on the whole it is a satisfactory absorbent. It suffers from two disadvantages, however, one being its high price, and the other the fact that it is a potential source of iodine from which the iodine can be liberated in a variety of ways with comparative ease. It is well known, for example, that potassium iodide solutions turn yellow, due to the liberation of iodine, on exposure to air and light.

In our iodine absorbers we use a 10 p.ct. solution of potassium iodide. The solution is prepared in batches of about 600 c.c. by adding 60 grammes of the iodide to 600 c.c. of water. Although using reagents of "A.R." quality, we have not, out of 25 preparations, had a single batch which, after standing for 24 hours, failed to yield an appreciable colouration with starch solution, and which did not show a progressive increase from day to day in the titratable iodine. The average amount of N/500 sodium thiosulphate solution required to discharge the colour of the indicator for solutions one day old was 0·3 c.c., while the daily increase was variable but averaged 0·03 c.c.—a quantity just sufficiently important to be taken into account in our long-period tests.

When making carbon monoxide determinations it is our practice to pipette from the stock bottle two portions of 25 c.c. of 10 p.ct. potassium iodide solution into spare absorbers whenever the iodine absorbers are filled for a test. These spares are allowed to stand beside the absorbers as "blanks," and are titrated in precisely the same way when the collected iodine is titrated. The solution in the spares is thus exposed for the same length of time to the same conditions of light, temperature, and contact with glass (from which alkali might be derived) as the test absorbers. Since the "blanks" contain a small amount of free iodine, we are sure that the potassium iodide contains no free alkali; the sequence of colour changes is the same, and the final end-point is approached in a similar manner for both. The amount of iodine collected therefore, which is the difference between the "blank" and test titration, can be accurately determined without it being necessary to know the amount of iodine required to react with the indicator. In our work the "Potassium Iodide Blank" is always determined, and deducted from the actual titration. The "blanks" differ from the test absorbers in so far that the former solution is not subjected to prolonged bubbling with the residual products of combustion. This could be secured by inserting the absorbers in the train—say, between R and S (fig. 1)—but they would then be liable to yield too high a correction, due to traces of iodine carried over from R.

A number of tests have been made to determine whether the alkali of the glass of these bottles absorbed small quantities of iodine. All we have observed, however, is the small gain quoted above, which is possibly the balance between decomposition of potassium iodide and absorption by the glass. We know that 25 c.c. of N/1000 iodine in 10 p.ct. potassium iodide solution stored in these bottles shows a barely perceptible loss in 24 hours when ground glass stoppers are used, while if rubber stoppers are used a titration loss of 0·5 c.c. is observed.

The selection of a suitable strength for the potassium iodide solution was determined by experiment. Solutions were made up containing known amounts of potassium iodide and such an amount of iodine as might be expected during a carbon monoxide determination—actually the equivalent of 10 c.c. of N/500 iodine in 25 c.c. of the solution was used. Duplicate portions of 25 c.c. of each of these solutions were placed in iodine absorbers, one of which was retained as a comparison vessel, while purified air was drawn through the other exactly as during a carbon monoxide determination. The contents of the two absorbers were then titrated in the usual manner. The results were as follows:

1. Aqueous iodine solution without potassium iodide. Initial strength about N/1000. The iodine could be completely removed by bubbling with 10 litres of air.
2. 1 p.ct. potassium iodide solution. Lost 25 p.ct. of its iodine when treated with 10 litres of air.
3. 5 p.ct. potassium iodide solution. Lost only 2 p.ct. of its iodine when similarly treated.
4. 10 p.ct. potassium iodide solution. The loss was so small as to be masked by other irregularities.

On the basis of the above tests a 10 p.ct. solution of potassium iodide was adopted for the absorbent. Difficulty arose, however, for small amounts of iodine give a pink or purple colouration with starch in such concentrated solutions, instead of the characteristic blue; further, the tint and intensity of the colour are both affected by small variations in the concentration of the solution, and the end-point becomes much less definite than when titrating N/500 sodium thiosulphate and iodine solutions against one another in the presence of less than 1 p.ct. of potassium iodide (see *ante*). This difficulty with the indicator rapidly decreases as the solution is diluted, but it was not practicable to dilute (say) tenfold, for loss in sensitivity of the indicator would have resulted. A compromise was therefore effected by using a 10 p.ct. solution in the absorber, but diluting this to 3⅓ p.ct. before the titration was completed. As we have uniformly employed 25 c.c. of potassium iodide solution in the absorbers, this means that the volume of the solution undergoing titration is made up to 75 c.c. with distilled water immediately before the last c.c. or so of sodium thiosulphate solution is added. The volume of liquid thus allowed is sufficient for washing the iodine from the bulb into the bottle, and permits of the titration being completed therein.

Weighed quantities of decinormal iodine solution equivalent to 20 to 25 c.c. N/500 sodium thiosulphate solution were titrated in aqueous solution and in 3⅓ p.ct. potassium iodide solution respectively, and the results showed that the iodine could be quantitatively titrated in the presence of that amount of potassium iodide.

The following table indicates the colour changes which occur when titrating iodine with N/500 sodium thiosul-

phate solution in 3½ p.ct. potassium iodide solution, discharge of the colour being taken as the end-point.

Drops of Solution.	Distance from End-Point in c.c.	Appearance of Solution.
31	1·00	Pale lemon yellow, followed by appearance of a pure blue on adding 1 c.c. of starch solution.
24	0·79	First trace of purple appears.
19	0·62	Distinct purple, blue predominating.
14	0·46	Purple, with red predominating.
9	0·30	Strong pink, with no trace of blue.
4	0·13	Pale pink, with trace of yellow.
1	0 03	Faint trace of colour, but indefinable.
0	0·00	Colourless.

It will be observed that the whole of these changes are covered by less than one drop of the decinormal solution commonly employed in iodine titrations. The titrated "blanks" are retained and are used as comparison vessels in deciding the end-point in the titration of the iodine liberated from the iodine pentoxide. We have already indicated the necessity of good diffused daylight and colourless bottles for the determination of these end-points. The final stages of the titration, also, must not be hurried, as the indicator slowly changes colour and fades. We have therefore adopted a time of 3 to 5 minutes for completion of titration.

Upon reviewing the results of about 160 titrations of "Potassium Iodide Blanks," made in pairs by the methods described above and covering a period of several months, we find that the average difference between duplicate titrations has been a little more than one drop of N/500 sodium thiosulphate solution (actually 0·040 c.c.). In only 12 p.ct. of the cases has the difference been greater than two drops (0·06 c.c.), so that the "blanks" would appear to be reliable within ± 1 drop—*i.e.*, ± 0·03 c.c.

Iodine Pentoxide "Blanks" at 140° and 120° C.

In view of the large quantity of iodine pentoxide (80 grammes) in each reaction tube compared with the small amount of iodine liberated during a normal carbon monoxide determination (usually less than 2 mg.), the stability of the iodine pentoxide at the working temperature, and freedom from irregular decomposition are matters requiring close investigation.

For a period of fourteen days the furnace was maintained at an average temperature of 140° C., and continuous tests were made by passing "purified" air through iodine pentoxide tubes occupying the position Q in trains of apparatus similar to that shown in fig. 1. The average duration of a test was 20 hours, and about 20 litres of air were dealt with in each test. Two complete trains of apparatus were in operation, and by means of suitable cross-connections any two of the four available iodine pentoxide tubes could be treated with air which had been purified by passage over the iodine pentoxide in the other pair. Such "purified air" should be without further action upon iodine pentoxide. Some iodine was, however, always collected; and this was determined and expressed as its equivalent in parts of carbon monoxide per million parts of air drawn through the apparatus. (The potassium iodide blank (*q.v.*) was deducted before making the calculation.)

The results were very concordant, and we were unable to detect differences in the behaviour of the four iodine pentoxide tubes. At a gas rate of 1 litre per hour the iodine collected was equivalent to 3·7 parts of carbon monoxide per million of air used. (Net titration about 0·6 c.c. of N/500 sodium thiosulphate.) Such an amount should clearly be deducted from any determination of carbon monoxide made under the same conditions of temperature and gas rate.

We have not investigated the matter fully, but from a limited number of tests, made at a gas rate of 0·5 litre per hour, in which an average blank of 5·2 parts of carbon monoxide per million was obtained for a temperature of 140° C., it would appear that this blank is to some extent influenced by the rate at which gas is passed through the apparatus. This may very well account for the lower blank obtained by the Government Chemist (*loc. cit.*), who with a gas rate of 5 litres per hour obtained a blank of 2 to 3 parts of carbon monoxide per million at 150° C.

The temperature of the furnace was dropped to 120° C., and the tests were repeated for a further period of fourteen days. The blank was considerably reduced, and for a gas rate of 1 litre per hour averaged 1·7 parts of carbon monoxide per million for 120° C. This reduction of the blank is also indicated in the Government Chemist's communication, although the value there given for 120° C. is 0 to 1 part of carbon monoxide per million. Lest it might be thought that this drop in the blank was due to an improved condition of the iodine pentoxide resulting from prolonged sweeping with purified air, we reverted to 140° C. for a few days, and the original values of our blanks were obtained.

If the tubes are allowed to stand at the working temperature without gas sweeping through them, iodine is slowly evolved, and remains in the apparatus. It is therefore necessary that the apparatus should be swept with purified air immediately before starting a test. This is particularly important if the test is such that only a small amount of iodine is likely to be evolved. We have several times determined the amount of iodine accumulated in the apparatus after it has stood at 120° C. for a few hours, for two days, and for nine days; and it is rather curious that the iodine evolved apparently does not increase after the first 24 hours. This suggests that an iodine equilibrium is reached; but there is no corroborative evidence that this is the case.

From time to time, and especially if the iodine pentoxide tubes have been subjected to any abnormal treatment, blanks at 120° C. have been re-determined, and about forty results have now been accumulated. These indicate that for our present apparatus and procedure a deduction of 1·7 parts of carbon monoxide per million should be made for the "Iodine Pentoxide Blank." Very few of the results differ by more than 1 part per million from this mean value. As the titrations are so small, a test with 16 to 20 litres of purified air is necessary to obtain a reliable check determination of the blank.

Carbon Monoxide in Air.

Carbon monoxide may be regarded as a normal constituent of town air, but the amount present is subject to considerable variations, depending upon the character of the neighbourhood, meteorological conditions, and the time of the year. It will be exceptional for the amount to exceed 10 parts of carbon monoxide per million of air, and 5 parts per million, or less, may be regarded as normal. The air inside buildings which are warmed or lighted by the combustion of solid or gaseous carbonaceous fuels may show the presence of carbon monoxide in greater amounts than this. In determining the production of carbon monoxide by an appliance, therefore, it is necessary to make allowance for the carbon monoxide in the air which is supplied for combustion and dilution of the products of combustion. The correction on this account may become very important when the amount of carbon monoxide produced by the appliance is small.

We have made a large number of determinations of the amount of carbon monoxide in the air, both inside and outside our testing-room, most of these being of about 17 hours' duration and treating about 18 litres of air. In numerous cases duplicate tests have been conducted simultaneously on our two trains of apparatus. It is exceptional for duplicates to differ by more than 2 parts per million, and agreement within 1 part per million is frequently obtained. As the apparatus and procedure are uniform, the difference in results obtained from day to day must be ascribed to genuine variations in the carbon monoxide content of the atmosphere.

For testing the air outside the building, samples were drawn from a point 3 ft. outside the window and overlooking the works yard. There is a certain amount of motor traffic here, but disturbance due to this cause (hydrocarbons and carbon monoxide from exhaust gases) was largely eliminated by running the tests overnight. Of 40 tests conducted on the air outside the building, the highest showed 10 parts of carbon monoxide per million of air, and the lowest 1·0 part per million; but there was a well-marked connection between the carbon monoxide figure and atmospheric conditions.

The normal amount of carbon monoxide in the air of this district (Meadow Lane, Leeds) appears to range between 3 and 6 parts per million, with an average value of

4·5 parts per million. Values greater than 6 parts per million were usually associated with little wind or with a stagnant atmosphere such as prevails during a fog. There were several groups of foggy days during the period in question, and at the end of three days of continuous dense fog the remarkable concentration of 25 parts of carbon monoxide per million of air was reached. On the other hand, strong winds between north-east and north-west—*i.e.*, from the direction of the better-class residential and moorland districts—usually caused the carbon monoxide content of the air to fall well below the average.

It should be pointed out that our room is situated in a congested area and on a gas-works site, both of which might give rise to a local concentration of carbon monoxide a little above the normal. With a wind from the south, we have had on occasion unmistakable evidence of carbon monoxide from the "blow" gases of the water-gas plant, although this is 350 yards away and the intervening space is much broken up by buildings. On only a few occasions have tests been abandoned on this account, and we have experienced no inconvenience from the coal-gas plant nearer at hand. Most of the tests were conducted in the colder months of the year (November to March), when from the large amount of artificial heating and lighting necessary, the carbon monoxide production in the district might be expected to be rather greater than the average for a complete year.

In connection with tests on gas appliances, the carbon monoxide in the air of the room is of more direct importance than that in the outside air. We have therefore made many determinations upon the air of the room in which tests with gas appliances were carried out; some of them in duplicate with two trains of apparatus; others during simultaneous comparisons of air inside and outside the building; and the remainder concurrently with tests upon the products of combustion from gas fires. The average value found for the carbon monoxide in the air of the room was 18 parts per million, a quantity considerably in excess of that found for the air outside the building.

It was of the utmost practical importance that we should be able to show that this carbon monoxide was not due to the escape into the room of products of combustion from the gas fires under test, or in use for heating the room.

The material evidence was as follows:

1. There was at all times a good draught up the flue to which the gas fire was connected.
2. The amount of carbon monoxide in the air of the room was not sensibly altered by changing the fire under test.
3. When the gas fire was extinguished, the amount of carbon monoxide in the air of the room was very little altered.
4. It would have been impossible for products of combustion to have been brought into the room to give the observed concentration of carbon monoxide without noticeable discomfort from sulphur compounds present in the products of combustion.
5. It would have been impossible for products of combustion to have been brought into the room to give the observed concentration of carbon monoxide without at the same time increasing the CO_2 by a measurable amount; and no unusual increase in CO_2 over that of the outer air was ever observed.

The evidence is therefore decidedly against the suggestion that the carbon monoxide in the air of the room was derived from the gas fires, and so far as the removal of their products of combustion is concerned they may be regarded as perfectly satisfactory.

The fact that the carbon monoxide was obtained without an equivalent amount of CO_2 suggested the presence of unburned gas in the room, and we were eventually able to trace the trouble to leakage from a defective gas fitting in an inaccessible corner of the room; since removing this, more normal carbon monoxide figures for the air of the room have been obtained.

This matter has been considered so fully because it is not generally realized that neither the normal carbon monoxide content of the atmosphere nor the usual variations in its carbon monoxide content can be disregarded when examining the products of combustion from those gas appliances which evolve only small amounts of carbon monoxide.

Action of Various Gases on Iodine Pentoxide.

Since iodine pentoxide is used for determining carbon monoxide because of its power of oxidizing that gas selectively in the presence of other oxidizable gases, it was of great importance that we should examine the behaviour towards iodine pentoxide of such other gases as were likely to be met with in products of combustion, preferably when mixed with a large excess of air and at such concentrations as might be met with in practice. It was considered that tests could most usefully be made with concentrations lying between 0·5 p.ct. and 0·025 p.ct. of the gases involved (5000 and 250 parts per million respectively). The usual defects in preparing such mixtures for control tests are failure to allow for carbon monoxide normally present in air, and inability to avoid uncertain changes in concentration due to the action of the confining liquid.

We therefore decided to measure definite small quantities of each gas over mercury and to prepare the desired mixtures with air which had been purified by passage over iodine pentoxide. The mixtures were not made in the usual way by putting the constituents together and allowing them to stand, but by discharging the accurately-measured volume of gas at an appropriate and approximately constant rate into a uniform stream of purified air on its way to the iodine pentoxide tube.

The apparatus used is referred to as the "Drip Apparatus" (see fig. 8), and it is inserted at H in fig. 1, the

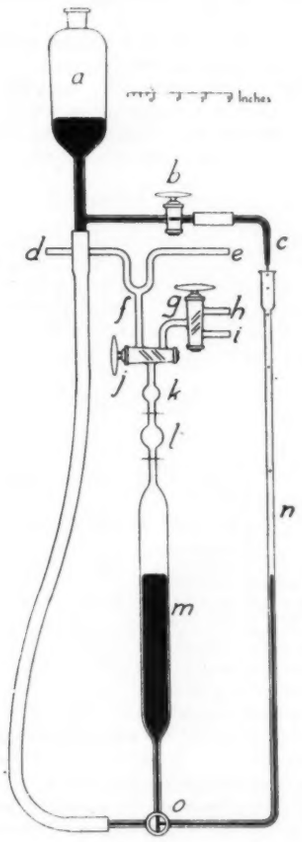


Fig. 8.—"Drip" Apparatus.

portion of the train to the left of H supplying the necessary "purified air." The sample of gas to be used is confined under pressure in a mercury sampler connected to the tube (*h*). The mercury reservoir (*a*) is lowered and the bulbs (*k*) and (*l*) are filled through cocks (*g*) and (*j*), after which this gas is rejected *via* (*i*). This is done two or three times. Finally an amount of gas is drawn in, slightly more than will fill (*k*), or (*k*) *plus* (*l*), the volumes of which have previously been accurately determined by

weighing the amount of mercury they hold; (*j*) is closed and (*g*) is opened to the atmosphere. After standing for some time to attain a steady temperature, which is noted, the mercury is brought exactly to the graduation on (*k*) or (*l*) by manipulation of the mercury reservoir (*a*) and the cock (*o*). Cock (*j*) is then momentarily opened to atmosphere to relieve the excess pressure in the bulbs, and the barometric height is noted. The data obtained allow the volume of gas to be corrected for temperature and pressure.

It would not be practicable to spread the discharge of the small volume of gas contained in (*k*) and (*l*) over a period of one or two hours, so the reservoir (*a*) is lowered, and purified air is drawn in *via* (*d*), (*f*), and (*j*) from the stream of air which is sweeping the train through (*d*)–(*e*). The volume of air used may conveniently be 100 to 120 c.c., but it need not be exactly known. Cock (*j*) is closed and the gases are allowed to mix by diffusion. In the meantime a fresh iodine absorber R and aspirator S (fig. 1) are attached to the end of the train, and sweeping is started at a convenient rate. Cock (*o*) is turned to connect (*n*) and (*m*), but to cut off the reservoir (*a*), which is raised into the position shown. Cock (*j*) is turned to communicate with (*f*), and (*b*) is opened to allow mercury to drip from the jet (*c*). This jet is chosen by trial to deliver sufficient mercury to fill (*m*), (*k*), and (*l*), and the tube (*f*) up to the lowest point of the bend of (*d*)–(*e*) in about two hours, and the quantity of mercury in (*a*) is adjusted so that the level automatically finishes at the right point. The gas is thus gradually driven into the stream of purified air passing along the tube (*d*)–(*e*), and the volume of air used is noted when all gas has been expelled from the drip apparatus. Sweeping is continued as usual to carry forward the reacting gas and iodine accumulated in the apparatus.

From the above description it will be seen that we have exact information as to the total quantity of reacting gas passed over the iodine pentoxide, together with an approximate idea of the concentration at which it passed over the iodine pentoxide. A number of gases of special interest and importance were examined.

1.—Carbon Monoxide.

Carbon monoxide was prepared by the action of concentrated sulphuric acid upon formic acid, the gas being purified by passage through potash solution and by standing over potash in a mercury-sealed gasholder. The gas contained 98·9 p.ct. of carbon monoxide.

The following results were obtained:

—	A.	B.	C.	D.
Vol. of gas taken in c.c. at 60° Fahr. 30 in. bar (wet)	2·382	2·405	2·397	2·388
Vol. of carbon monoxide taken in c.c. at 60° Fahr. 30 in. bar. (wet)	2·356	2 379	2·371	2·362
Approx. duration of test in hours*	1·6	1·6	9·5	9·2
Vol. of purified air, in litres, used during passage of carbon monoxide	1·7	1·8	9·4	8·9
Concentration of carbon monoxide, p.ct.	0·14	0·13	0·024	0·027
Vol. of carbon monoxide in c.c. deduced from iodine liberated†	2·351	2·313	2·375	2·332
Equivalent p.ct. of carbon monoxide taken	99·8	97·2	100·2	98·7

* Time of passage of reacting gas, excluding sweeping time.

† Corrected for potassium iodide and iodine pentoxide blanks.

In the above experiments made with mixtures of pure carbon monoxide and air in proportions such as might be met with during the examination of products of combustion, there is good agreement between the amount of carbon monoxide taken and that deduced from the iodine liberated. If, therefore, certain other gases are first removed, it is clear that carbon monoxide at these dilutions can be quantitatively determined by means of iodine pentoxide.

2.—Town Gas.

It was important that the effect of town gas upon iodine pentoxide should be investigated, because small amounts of unburned gas may find their way into the products of combustion, or into the air supplied to the gas appliance under test.

The following tests were therefore made:

—	A.	B.
Volume of gas taken in c.c. at 60° Fahr. 30 in. bar. (wet)	7·44	7·41
Approx. duration of test in hours*	1·8	2·6
Vol. of purified air, in litres, used during passage of gas	1·8	2·6
Concentration of gas p.ct.	0·42	0·28
Vol. of "CO" in c.c. deduced from iodine liberated†	2·66	2·68
Equivalent p.ct. of "CO" in gas used	35·8	36·2

* Time of passage of reacting gas, excluding sweeping time.

† Corrected for potassium iodide and iodine pentoxide blanks.

The sample of town gas used in the above tests contained 16 p.ct. of carbon monoxide, and it is clear from the above experiments that the iodine pentoxide determination indicates an amount of carbon monoxide considerably in excess of that known to be present.

Carbon monoxide is a characteristic constituent of town gas which is not found in sewer gas. The iodine pentoxide reaction has sometimes been used for differentiating small gas leaks suspected of being due to one or other of these gases, and the extent of the town gas leakage has been deduced from the amount of "carbon monoxide" found and the known percentage of carbon monoxide in the local gas supply. It is clear, however, that the extent of the gas leakage may be considerably overestimated if this plan is followed. Some light is thrown upon the discrepancy by the tests with other gases which follow immediately.

3.—Hydrogen.

The effect of hydrogen upon iodine pentoxide was examined because its presence in the products of combustion of gas is as likely as that of carbon monoxide.

The hydrogen for our tests was prepared by the action of pure zinc upon 10 p.ct. sulphuric acid, and was purified by passage through potash solution. Clearly, it could not contain carbon monoxide. Analysis showed it to contain 97·2 p.ct. of hydrogen.

The following tests were conducted:

Temperature of Iodine Pentoxide Tube	140° C.	120° C.
Vol. of gas taken in c.c. at 60° Fahr., 30 in. bar. (wet)	9·66	15·14
Vol. of hydrogen taken in c.c. at 60° Fahr., 30 in. bar (wet)	9·39	14·72
Approx. duration of test in hours*	3·7	3·5
Vol. of purified air, in litres, used during passage of hydrogen	3·5	3·0
Concentration of hydrogen, p.ct.	0·27	0·49
Vol. of "carbon monoxide" in c.c., deduced from iodine liberated†	0·058	0·007
Equivalent p.ct. of "carbon monoxide" in hydrogen used	0·62	0·05

* Time of passage of reacting gas, excluding sweeping time.

† Corrected for potassium iodide and iodine pentoxide blanks.

In the above experiments only a slight reduction of iodine pentoxide by hydrogen is indicated, which is smaller at 120° C. than at 140° C. The observed reduction might, however, be due to the presence of traces of hydrocarbons produced during the preparation of the hydrogen.

There would appear to be no difficulty in determining carbon monoxide in the presence of hydrogen where these two gases are present in comparable proportions, as in flue-gas mixtures, though without more detailed examination there might be some hesitation in using iodine pentoxide for the determination of carbon monoxide in the presence of large amounts of hydrogen.

4.—Methane.

It was of importance to know the behaviour towards iodine pentoxide of the paraffin hydrocarbons occurring in town gas. The "methane" used for our experiments was therefore prepared by removing the *unsaturated* hydrocarbons from coal gas with bromine, and then burning the residue at a dull red heat over copper oxide in the modified Bone and Wheeler gas analysis apparatus. The carbon monoxide and hydrogen were oxidized, and after treatment with potash left a residue of methane (with a little ethane) and nitrogen. The gas used contained 62·5

p.ct. of "methane," and the following test was made with this residue:

Vol. of gas taken in c.c. at 60° Fahr., 30 in. bar. (wet)	7·54
Vol. of "methane" taken in c.c. at 60° Fahr., 30 in. bar. (wet)	4·71
Approx. duration of test in hours*	1·9
Vol. of purified air, in litres, used during passage of gas	2·1
Concentration of "methane," p.ct.	0·22
Vol. of "carbon monoxide" in c.c., deduced from iodine liberated†	0·149
Equivalent p.ct. of "carbon monoxide" in methane used	3·16

* Time of passage of reacting gas, excluding sweeping time.
† Corrected for potassium iodide and iodine pentoxide blanks.

It will be seen that iodine pentoxide was not greatly affected at 120° C. by the paraffin hydrocarbons of town gas at a "methane" concentration of 0·22 p.ct. Determinations of carbon monoxide in weak mixtures of town gas and air may therefore be made by means of iodine pentoxide without any error of consequence being introduced by the presence of the accompanying paraffin hydrocarbons.

The proportion of carbon monoxide to paraffin hydrocarbons in products of combustion is unknown, and it is therefore not possible at present to indicate the extent to which carbon monoxide determinations are affected in this case, but the matter is receiving further attention.

5.—Unsaturated Hydrocarbons.

It was not possible to isolate the unsaturated hydrocarbons of town gas and determine their effect upon iodine pentoxide in the foregoing manner, but the desired information was obtained by making comparative tests with a sample of town gas from which the unsaturated hydrocarbons had been removed by treatment with bromine followed by potash.

The results were as follows:

—	A.	B.
Vol. of gas taken in c.c. at 60° Fahr., 30 in. bar. (wet)	7·48	7·38
Approx. duration of test in hours*	2·25	1·75
Vol. of purified air, in litres, used during passage of gas	2·4	1·8
Concentration of gas, p.ct.	0·31	0·41
Vol. of "carbon monoxide" in c.c., deduced from iodine liberated†	1·35	1·34
Equivalent p.ct. of "carbon monoxide" in gas used.	18·0	18·2
Known p.ct. of carbon monoxide in gas used	15·7	14·7

* Time of passage of reacting gas, excluding sweeping time.
† Corrected for potassium iodide and iodine pentoxide blanks.

In the above experiments the amount of "carbon monoxide" deduced from the reduction of iodine pentoxide is still distinctly greater than the amount known to be present in the gas used. When comparison is made with the town gas experiments, it is clear that the unsaturated hydrocarbons liberate much more iodine, volume for volume, than does carbon monoxide, and that they are mainly responsible for the discrepancy. Their removal permits of a much closer approximation to the true carbon monoxide content being obtained.

The small outstanding discrepancy in the present tests may be due to the joint action of hydrogen, methane, and carbon monoxide, but it is more probably due to imperfect removal of unsaturated hydrocarbons by bromine, or to the presence of volatile brominated compounds in the residual gas. Sinnatt and Slater also (Bulletin XIII, Lancashire and Cheshire Coal Research Association, "The Determination of Carbon Monoxide in Vitiated Air," 1923, pp. 16-18) have found fault with the use of bromine for a similar purpose, and recommend 10 p.ct. fuming sulphuric acid as an alternative. Activated charcoal has been used as an absorbent for unsaturated hydrocarbons by the American Bureau of Standards, but on account of its properties we should prefer not to use this material in a train of apparatus for the determination of small amounts of carbon monoxide. Liquid air condensation has been successfully applied by a number of workers.

In addition to hydrocarbons derived from the original gas, it is recognized that small amounts of unsaturated hydrocarbons may be formed during the chemical rearrangements which occur during combustion, especially when this takes place with a restricted air supply; in such circumstances precautions would be necessary to ensure their removal before determining carbon monoxide.

6.—Benzene.

The influence of benzene upon iodine pentoxide was studied because it forms a large proportion of the heavy hydrocarbons of town gas, and the experiments might be expected to throw some light upon the results obtained in the preceding section. If, under the conditions of testing, benzene were completely oxidized to carbon dioxide and water, one volume of benzene vapour would be returned as 15 volumes of carbon monoxide, so that even small amounts of benzene would cause serious irregularities in carbon monoxide determinations. This was taken into consideration in deciding upon the concentration of benzene vapour to be used.

The benzene was introduced into the drip apparatus in the form of a measured volume of air saturated with benzene vapour at a known temperature, and was immediately further diluted to avoid precipitation of benzene.

The test gave the following results:

Vol. of benzolized air taken in c.c. at 60° Fahr., 30 in. bar. (wet)	7·61
Vol. of benzene vapour therein at 60° Fahr. 30 in. bar (wet)	0·612
Approx. duration of test in hours*	1·8
Vol. of purified air, in litres, used during passage of benzene vapour	2·0
Concentration of benzene vapour, p.ct.	0·031
Vol. of "carbon monoxide" in c.c., deduced from iodine liberated†	4·425
Equivalent p.ct. of "carbon monoxide" in benzene vapour used	723

* Time of passage of reacting gas, excluding sweeping time.
† Corrected for potassium iodide and iodine pentoxide blanks.

The above table indicates that benzene vapour readily reduces iodine pentoxide, liberating as much iodine as would 7·23 times its volume of carbon monoxide. Where circumstances are such that the presence of benzene vapour may be expected, it is clear that it must first be removed before the carbon monoxide can be accurately determined; and liquid air condensation probably furnishes the most convenient means of attaining this end.

We have not determined the composition of the gases leaving the iodine pentoxide tube when using benzene vapour, but it will be observed that the amount of iodine liberated is only about half that which might be expected from complete oxidation of the benzene. It may be that the oxidation is not quantitative or that in the presence of iodine pentoxide some iodine is consumed in the formation of iodo-benzenes.

It should also be mentioned that after the above experiment using benzene vapour at a concentration of only 0·03 p.ct. there was considerable difficulty in restoring the iodine pentoxide tube to its normal state, and it was necessary to sweep with purified air for 48 hours before the tube would again yield a satisfactory iodine pentoxide "blank."

7.—Oxides of Sulphur.

During combustion of town gas practically the whole of the sulphur is oxidized, although a little may escape combustion and a further quantity may react with hot metal fittings to form sulphides directly.

In certain types of gas appliances—*e.g.*, condensing stoves, water heaters and wash-boilers—where condensation of water vapour from the products of combustion is likely to take place, some interest attaches to a knowledge of the proportion of sulphur escaping in the products of combustion and that remaining in the appliance and leading to corrosion. E. W. Smith showed 70 p.ct. of the total sulphur escaping in the products of combustion from condensing stoves (Second Report of the Gas Heating Research Committee of the Institution of Gas Engineers, 1910). For other appliances it may be sufficient to assume that the whole of the sulphur is oxidized and passes into the products of combustion, and to investigate corrosion not by analysis of the products of combustion, but by examination of the gas appliances and of deposits and incrustations sometimes found upon them.

We have not as yet made a detailed study of the sulphur compounds in products of combustion, but have evidence that sulphur dioxide is the main form in which the sulphur is found. This would interfere with the determination of carbon monoxide by means of iodine pentoxide. Two things may happen—(1) the sulphur dioxide

may be oxidized by the iodine pentoxide with the liberation of iodine, and in the presence of traces of water vapour may form sulphuric acid, leading to a moist and unreliable condition of the reagent, difficult to rectify; (2) if the sulphur dioxide is not oxidized, it will pass forward to the iodine absorbers where it will readily react with the iodine in solution, thereby reducing the amount to be titrated with sodium thiosulphate, and leading to low carbon monoxide figures.

The amount of sulphur usually present in town gas would produce serious errors whichever of the above reactions takes place, and the removal of sulphur dioxide is therefore essential for securing accurate carbon monoxide determinations. In our tests it was satisfactorily removed by the potash bulbs.

8.—Oxides of Nitrogen.

It has been known for many years that nitrates were present in rain water, and that considerably greater quantities were found in the rain water of towns than in that of country districts. There is little doubt that the extra nitric acid found in the air of towns is due to the oxidation of nitrogen during the combustion of solid and gaseous fuels. The amounts produced are very small and the estimates made by various workers are not concordant. It is alleged that the oxides of nitrogen have an irritant action on the mucous lining of the throat and lungs, and also have specific poisonous properties.

The oxides of nitrogen may give rise to irregularities in the determination of carbon monoxide in products of combustion, since they are capable of reacting with potassium iodide to liberate iodine, being reduced to nitric oxide in so doing. In the presence of oxygen, which invariably forms part of the diluted products from gas appliances, the nitric oxide can regenerate the higher oxides of nitrogen, so that the cycle involving the liberation of iodine can be repeated indefinitely, a large amount of iodine being liberated through the agency of small quantities of oxides of nitrogen. Thus, even if the amount of oxides of nitrogen can be accurately determined, the correction that should be applied to the carbon monoxide figure is still uncertain.

It would be preferable to avoid this difficulty by removing the oxides of nitrogen. Following Teague (J.I.E.C., 1920, Vol. 12, p. 964), the Government Chemist inserts a condensing tube of type VI., fig. 3, at a convenient point —say, N, in fig. 1. This tube is immersed in liquid air contained in a Dewar vessel, thereby cooling the gases to − 183° C. and removing various condensible products which might interfere with the carbon monoxide determination, among them being the oxides of nitrogen.* Provision has been made for the insertion of a liquid-air condensing tube in our train of apparatus, but in the tests we have so far made its use has not been considered essential.

A number of experiments have been conducted bearing upon the removal of oxides of nitrogen by purely chemical means, which were regarded as a more convenient alternative where simultaneous determinations of carbon monoxide and oxides of nitrogen were not required. Five litres of products of combustion from a well-aerated Bunsen burner were drawn directly through one of our absorbers containing a 10 p.ct. solution of potassium iodide. No iodine was liberated. When iodine was added to the potassium iodide in the absorber and the test repeated, the added iodine was rapidly removed. It is evident that the effect of sulphur dioxide in the products of combustion (see previous section) was sufficiently great to mask the effects of oxides of nitrogen.

Very careful experiments were made on the products of combustion from a gas fire, using trains of apparatus similar to fig. 1 and complete in all respects save for the omission of the iodine pentoxide tubes. Any iodine liberated must therefore be due to causes other than the interaction of carbon monoxide and iodine pentoxide. Soda-lime and potash solution were used as alternatives for the removal of carbon dioxide, sulphur dioxide, &c. In neither case was there any unusual liberation of iodine in the absorbers. While, therefore, we do not dispute the formation of oxides of nitrogen during combustion, or their effect upon potassium iodide solution, it is clear that in these experiments they were not going forward in sufficient quantity to cause appreciable inaccuracy in the carbon monoxide determination.

* Haber and Coates and also Terres have used liquid air condensation for the removal of oxides of nitrogen from products of combustion. See "J. für Gasbeleuchtung," No. 28, 1914, p. 700.

Accuracy to be Expected of Results.

The quantity of carbon monoxide in a sample of products of combustion is calculated from the amount of iodine collected in the iodine absorbers, allowance being made for the potassium iodide and iodine pentoxide "blanks." Clearly, the accuracy of the carbon monoxide determination is dependent in the first place upon the absence, or preliminary removal, of such other gases as might also liberate iodine from iodine pentoxide or consume some of the iodine already liberated (see previous sections on "Action of Various Gases on Iodine Pentoxide"). The extent of the error on this account is very difficult to assess.

It has been shown (see "Quantities to be Used") that the volume of products dealt with, and the weight of CO_2 collected, can usually be arranged so that an accuracy of ± 2 p.ct in these quantities is attainable.

The remaining factor is the precision with which the liberated iodine can be collected and determined. So far as mere titration errors are concerned, the potassium iodide "blanks" seem to indicate that consistent results within ± 0·03 c.c. can be obtained. When, however, the iodine pentoxide "blanks" are considered, involving the sweeping of trains of apparatus, and the collection and titration of iodine, the concordance of results is not quite so good, and is apparently represented by ± 0·1 c.c. (corresponding with ± 0·7 parts of carbon monoxide per million on a test using 16 litres of purified air). A similar accuracy is suggested by the agreement between *simultaneous* tests on either air or products of combustion. Our experience indicates that this quantity (± 0·1 c.c.) is not greatly influenced by the volume of products used.

AERATION OF HIGH-PRESSURE LIGHTING BURNER.

In order to complete the investigations of the Thirteenth Report, aeration tests were made upon a high-pressure lighting burner, a 1000 C.P. Keith lamp being used for the purpose.

The scope of the tests was limited because only one quality of gas was available, and because the burner was provided with a single injector orifice of fixed dimensions, adjusted for working at 68 in. water gauge upon the high pressure gas supply in Leeds. The only variable factor, therefore, was the air regulation, brought about by screwing backwards or forwards a plunger working transversely in the body of the burner between the nipple and the superheater. The tests were made with the usual glass globe on the lamp.

The lamp in question is fitted with a "thermostat," or valve controlled by a bi-metallic strip. The thermostat cuts down the degree of aeration at first until warming of the superheater causes the valve to open and allows the full aeration to be reached. The initial degree of aeration will depend upon the setting of the thermostat, and tests were not made with the cold burner. We have, however, determined the degree of aeration within the first 2½ minutes after lighting the lamp. (It is supposed to take about 10 minutes for the thermostat to reach its equilibrium position). As with low-pressure burners, the gas rate is appreciably greater with the cold burner than after warming up, but owing to the action of the thermostat the degree of aeration in these early stages is hardly distinguishable from that of the burner in its steady state. The flame during these initial stages was rather fierce, and the thermostat might with advantage have been closed slightly.

The degree of primary aeration was determined for a setting of the air regulator which was found to yield the best illuminating power with the quality of gas in use. It was a matter of securing the best fitting flame for the mantle, combined with the highest degree of local heating; and with the grade and pressure of gas used, this condition was reached with a degree of aeration which was 89 p.ct. of the theoretical air requirement of the gas. This setting of the air regulator was obtained when the screw

was withdrawn 1⅜ turns from the position in which the tip of the plunger made contact with the wall of the mixing tube. The effect upon the degree of aeration of one complete turn of the air regulator (screwed 19 threads per inch) in either direction from the optimum adjustment was also determined.

In order to ascertain the maximum degree of aeration obtainable with the pressure and specific gravity of gas used, tests were made with the air regulator withdrawn so as to present no obstruction in the injector tube (13½ turns for normal setting). The illumination was distinctly inferior to that for the normal setting. It will be observed that, while the aeration exceeds the theoretical air requirement for the grade of gas employed, and is higher than in any of the low-pressure burners we have examined, the air-gas ratio is not remarkably high, despite the high initial pressure of the gas. With the existing setting of the thermostat, the lamp could not be started from cold with this degree of aeration, because of back-firing.

The gas had the following composition :

CO_2	5·0
O_2	0·5
C_mH_n	2·7
CO	17·4
H_2	44·8
CH_4	20·3
N_2	9·3
	100·0

Calorific value	472 B.Th.U. gross per c.ft.
Sp. gr. (dry air = 1)	0·52
Theor. air requirement	3·91 c.ft. per c.ft. of gas
Gas pressure	68 in. water gauge
Gas rate	18 c. ft. per hour at 68 in. pressure (includes 0·20 c.ft. per hour for by-pass)
Dia. of nipple orifice	0·045 in.

The results for various conditions of use were as follows :

Test No.	Position of Air Regulator, &c.	Air-Gas Ratio.	Mean.
1	Normal setting of air regulator, test made in first 2½ minutes after lighting the lamp	3·63 3·53	3·58
2	Optimum setting of air regulator, after lamp had been running for 1½ hours	3·35 3·57 3·56 3·46	3·48
3	Air regulator turned one complete turn inwards from best position	2·94 2·75	2·85
4	Air regulator turned one complete turn outwards from best position	4·01 3·78	3·89
5	Air regulator fully open	4·63 4·53	4·58

Prof. J. W. COBB, introducing the Fifteenth Report, said :

The constitution of the Gas Research Sub-Committee has been strengthened during the year by the appointment of Mr. Hardie as an Institution representative, but has otherwise remained the same. Prof. Smithells has continued to act as Chairman, and has, we are glad to say, been able to resume that active interest in its affairs which we have come to expect of him, and which counts for so much in its working. Unfortunately, Prof. Smithells is not well enough to be here this morning, but has asked me to convey his apologies for his absence on that account.

I should like to refer to one pleasing feature of the work of this Committee, and that is the close and friendly association which has been established between us and the Gas Department of the City of Leeds. I need hardly stress the importance and value of such a connection. That has already been demonstrated by the work done for a number of years at Birmingham ; and now the provision of a working laboratory at Leeds, with other facilities close at hand to the University, has proved extremely useful. For this we have to thank the good offices of Alderman Ratcliffe, the Chairman of the Gas Committee, and Mr. C. S. Shapley, the General Manager of the Gas Department and a member of our Research Committee.

The first part of the work carried through by the Committee during the year has been a thorough investigation of the accurate determination of carbon monoxide. This has been in the hands of Mr. Wood and Mr. Howarth, to whom the thanks of the Committee are due for another demonstration of their experimental skill and resource. They have, as you know, been engaged in previous years, among other things, upon the study of the performances of gas appliances, with special regard to thermal efficiency. Now, attention has been turned to an equally careful study of the nature of the products of combustion from such appliances, and particularly the investigation and determination of any products of incomplete combustion which may be present, such as carbon monoxide. Such work, if the results obtained are to be entirely trustworthy—and they are of no use to us if they are not trustworthy—demands a careful elimination of every possible source of error, and the greatest possible care and judgment in the interpretation of numerical results when they have been obtained. The necessity for this extreme care has been realized by others, in the last year or two, who have had to face this problem ; and we are glad to take this opportunity of thanking Sir Robert Robertson, the Government Chemist, and Mr. Yates and Dr. Hartley, of Messrs. Radiation Ltd., for their readiness and willingness to give us the results of their own valuable work and inquiry at the outset of our investigation and before they had published anything themselves.

Mr. Wood and the Committee are now satisfied that they have in their hands a method which, with proper precautions, could be made to yield reliable results. It cannot be claimed that it is a simple method ; that is hardly to be expected. The different points that arise are discussed in the report before you, and the method so established is now being applied to the examination of different gas appliances, commencing with the gas fire.

It will be plain from this that the Fifteenth Report, as presented, is essentially a preliminary and interim report.

Mr. J. W. WOOD said : Prof. Cobb has already stated that this Fifteenth Report is preliminary to work that we are undertaking in connection with the investigation of the products of combustion from gas appliances—particularly any products which might be regarded as obnoxious or in any way dangerous. For one thing, as regards the gas engineer, it is rather unfortunate—and it is also unfortunate for the investigator—that these substances are present in extremely small quantities even in the products of combustion themselves ; and when you take into consideration that, before we can sample, without in any way interfering with the normal operation of the appliances, the products of combustion become considerably diluted with air (in some cases as much as 200 or 300 times), the small quantities of dangerous constituents which are present are so far diluted that it becomes a difficult matter indeed to determine them with accuracy. One of the chief constituents in which we were interested was carbon monoxide ; and after reviewing the various methods for determining carbon monoxide which seemed reasonable, we decided that some modification of the iodine pentoxide oxidation of carbon monoxide was the most suitable for our purpose. We have now developed this method in such a way that we can measure with accuracy carbon monoxide when present in such small quantities as 1 or 2 parts per million. Practically the whole of this report is an account of the method used, and of the precautions adopted in order to be certain that the iodine which is liberated from the pentoxide is that which has been liberated by the action of carbon monoxide—because, unfortunately, iodine can be liberated from the iodine pentoxide in other ways. It is certain that, in work which has been done in the past, this accidental evolution of iodine from iodine pentoxide has given rise to statements respecting the output of carbon monoxide when no carbon monoxide has been evolved. We have been able to find carbon monoxide as a normal constituent of town air, present to the extent, in winter time, of about 5 parts per million, and in the summer time of only 1 or 2 parts per million ; and some further work has been done since this report was put into print. It was presented to the Committee in May ; and the effects of the coal strike, as well as the normal summer reduction of carbon monoxide, have been noticeable, for we have found smaller quantities during the summer months and during the strike. Indoors we occasionally find small amounts of coal gas and carbon monoxide where solid fuel is burned—quantities which are far too small to be at all harmful, but sufficiently great to influence the tests, and to necessitate corrections for them. As this report is one almost entirely of chemical matters dealing with the precautions necessary to secure accurate tests, I think it would be better to say no more about it now, but to hope that on some future occasion we shall be able to present to you results of the examination of the products of combustion from appliances, as determined by the methods which we have developed in this Fifteenth Report.

[The discussion was taken jointly with that on the Sixteenth Report. See later page.]

SIXTEENTH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE.

STUDIES IN CARBONIZATION.

PART I.—INFLUENCE OF SIZE OF COAL.

Adopted by the Gas Investigation Committee, May 19, 1926.

[For "General Introduction" see the Fifteenth Report.]

SUMMARY.

The experiments described in this report consittute the first stage of an investigation commenced with the object of studying the influences of various factors on the yields and physical and chemical properties of the products obtained when different types of coal are carbonized. It was decided that the rates of gas production and the structure of the resultant cokes should be given special consideration. The factors enumerated included (*a*) the state of division of the coal, (*b*) the temperature of the retort and the duration of carbonization, (*c*) the blending of different types of coal with one another and with coke breeze, (*d*) briquetting with and without a binder, and (*e*) the nature of the inorganic constituents of the coal as charged.

Before the blending of coals with one another or with coke can be accomplished, the ingredients must be disintegrated. The first step is to ascertain the changes in the yields and qualities of the products obtained when selected coals of different types and in graded sizes of particles are carbonized under identical conditions.

In any investigation, in which the influences of various conditions of operation of a process are to be studied, it is essential that one factor at a time should be examined. In some instances, the resulting changes may be small, so that the most accurate control attainable of all factors is of importance, if reliable information is to be obtained. It was therefore necessary to construct an experimental carbonization apparatus specially designed to meet the requirements of the investigation. When the fundamentals have been studied in a small experimental plant, the factors of greatest importance may be selected and examined in a full-size commercial plant. With the requirements in view, the research staff designed and erected the experimental plant described in detail under the heading "Experimental Plant."

The retort, which was cast from an alloy of nickel, chromium, and iron, has proved satisfactory in operation for long periods at a temperature of about 1000° C. In order to ensure that the internal volume of the gas purifying apparatus is as small as possible, ammonia is removed by means of sulphuric acid, and sulphuretted hydrogen is absorbed in solutions of caustic soda. Attention should be drawn to the method of obtaining truly representative samples of the gas made, by an arrangement of two gas meters in parallel. A chart recorder is also installed for the purpose of automatically registering rates of gas production.

The gas coal used throughout the experiments was obtained from Nottinghamshire.

Five grades of sizes of the coal were prepared for the complete tests carried out. The largest grade passed through a screen with 1¼ in. mesh but remained on a ¾ in. screen; the limiting sizes of the smallest of the five grades were 10 mesh and 30 mesh.

The principal results of the tests are given in the two following tables:

Results per Ton of Coal as Charged.

Test	A.	B.	C.	D.	E.
Size of coal	1¼ in. to ¾ in.	¾ in. to ½ in.	½ in. to ¼ in.	¼ in. to 10 mesh	10 to 30 mesh
Time of carbonization, hours	2·75	2·75	2·75	2·75	2·75
Temp. of retort, °C.	976	978	978	977	979
Gas made, c.ft.	12,170	12,520	12,635	12,790	12,640
C.V. of gas, B.Th.U. per c.ft.	594	590	582	579	600
Therms in gas made per ton	72·3	73·9	73·5	74·1	75·8
Coke (dry) cwt.	13·1	13·1	13·0	12·9	12·9
Tar (dehydrated) gallons	8·3	7·9	7·8	7·3	6·2

Results per Ton of Coal as Charged.

Test	F.	G.	H.
Size of coal	¾ in. to ½ in.	½ in. to ¼ in.	10 to 30 mesh
Time of carbonization, hours	2·0	2·0	2·0
Temp. of retort, °C.	974–946	977–959	978–950
Gas made, c.ft.	12,120	12,345	12,375
C.V. of gas, B.Th.U. per c.ft.	596	587	599
Therms in gas made per ton	72·2	72·5	74·1
Coke (dry) cwt.	13·0	13·0	13·0
Tar (dehydrated) gallons	7·9	7·8	6·2

The figures given for the temperatures of the retort in the first five tests, represent the averages of the temperatures recorded at the beginning and end of the period of carbonization of each charge. The supply of heat to the retort setting was the same in all eight tests, but since the period of carbonization in Tests F, G, and H was only two hours, the average temperature of the retort at the end of this period was lower than at the beginning. The initial and final average temperatures for these three tests, therefore, are given. In general, the thermal value of the gas made, in therms (gross) per ton of coal, rose from 72·3 in Test A with the grade of coal 1¼ in. to ¾ in., to 75·8 therms in Test E with the grade 10 to 30 mesh. A similar increase with a reduction in the size of coal particles occurred in Tests F, G, and H, although the yields in these three tests were lower than in the Tests B, C, and E, with the same grades of coal, owing to the shorter period of carbonization. This increase in the total thermal value of the gas made with decreasing sizes of coal particles would appear to be due largely to an increase in the amount of secondary decomposition of tar, for in Tests A to E there was a gradual reduction in the yield of tar from 8·3 gallons to 6·2 gallons per ton of coal.

The weight of each charge of coal in Tests A to H was 30 lbs., and each test included two or more charges. The average figures for the volumes of purified gas made from a single charge of coal as the period of carbonization progressed are given in the following table.

Gas Made in C.Ft. per 30 Lbs. Coal as Charged.

Time of Carbonization.	Test.				
	A.	B.	C.	D.	E.
Hrs. Mins.					
0 30	77·6	77·5	74·2	70·3	66·9
1 0	123·4	120·9	115·4	111·6	108·0
1 30	150·3	151·6	146·3	143·8	141·2
2 0	156·9	161·5	161·7	162·8	160·9
2 30	159·5	164·3	165·4	167·2	165·3
2 45	160·5	165·1	166·4	168·3	166·4

In the early stages of carbonization the rates of gas production were greater with the larger sizes of coal than with the smaller sizes. For example, the volume of gas made when the carbonization had proceeded for one hour decreased from 123·4 c.ft. with the 1¼ in. to ¾ in. coal to 108 c.ft. with the grade 10 to 30 mesh. The rates of gas production then became greater with the smaller sizes than with the larger sizes, until at the end of 2¾ hours the total volumes of gas evolved from the smaller grades of coal were greater than from the larger grades. These considerations may be of the greatest importance when such a question is raised as the possibility of effecting a partial carbonization rapidly in a high temperature process.

Experiments were also conducted to determine the effect of altering the temperature of carbonization by about 25° C. The following figures with ¼ in. to 10 mesh coal are typical of the results obtained.

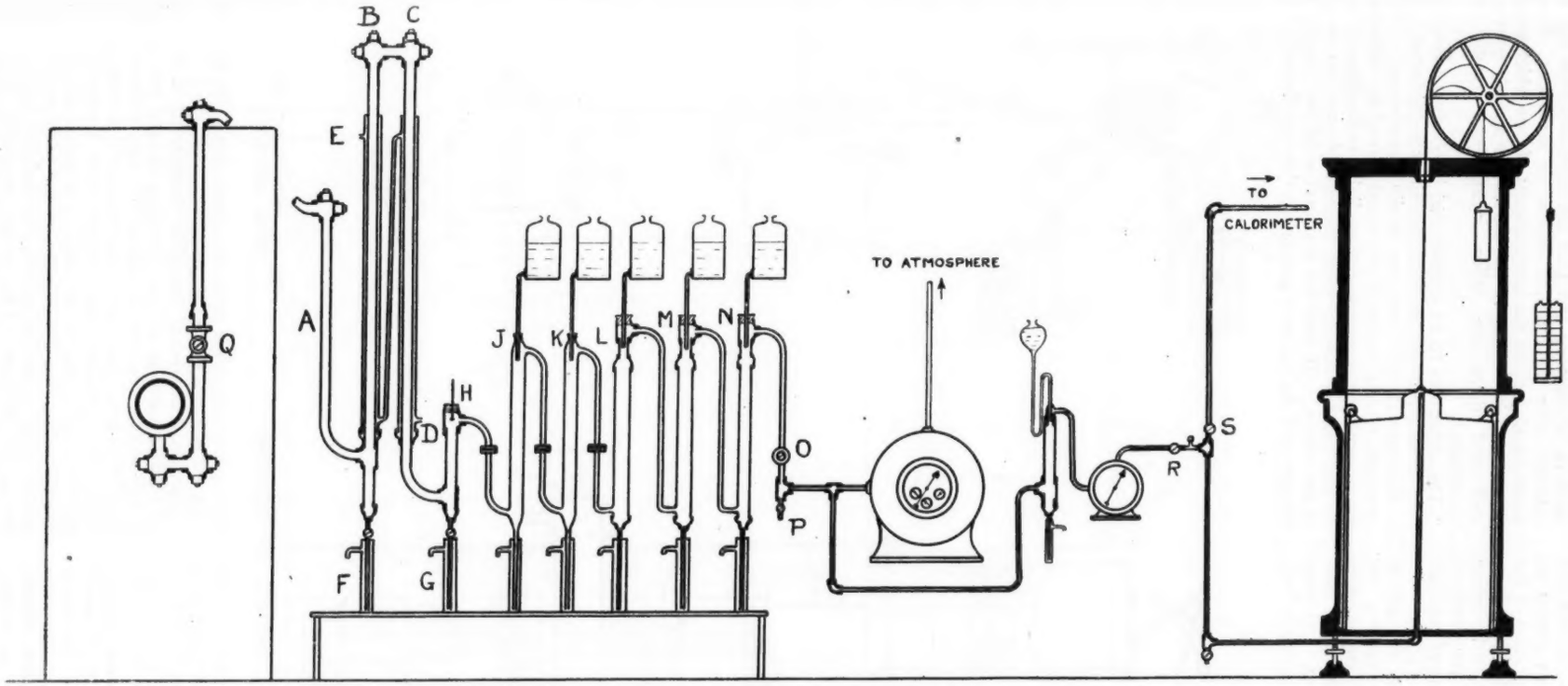


FIG. 1.—DIAGRAM OF EXPERIMENTAL CARBONIZATION APPARATUS.

Gas made in C.Ft. per 30 Lbs. of Coal as Charged.

Time of Carbonization.	Temperature of Retort, °C.	
	977.	1000.
Hrs. Mins.		
0 30	70·3	77·6
1 0	111·6	121 8
1 30	143·8	155·0
2 0	162·8	166·5
2 30	167·2	169·1
2 45	168·3	169·9

The great increase in the rate of gas evolution produced in the early stages of carbonization by raising the temperature of the retort by only 23° C., from 977° C. to 1000° C., will be observed. The figures demonstrate the importance of accurate temperature control.

The structures of the coke produced from the different grades of sizes of coal have been studied by the macro- and micro-examination of sections polished in plaster. The coke produced from the 10 to 30 mesh coal was more uniform in structure than the coke from the larger grades of coal. Further, in the coke from the 10 to 30 mesh coal the walls of the larger cells contained a greater number of very small pores.

DETAILED DESCRIPTION OF INVESTIGATION.

Research Chemist.—A. Parker.

Research Assistants.—H. Kerr and A. C. Monkhouse.

INTRODUCTION.

The main object of the investigation, of which the first stage is described in this report, is a study of the various factors which may influence the yields and physical and chemical properties of the products obtained when coal is carbonized. Among the many factors which must be taken into account in a complete study of the subject, the following should be given consideration.

1. The physical state of the coal to be carbonized as determined by the average size and the variation in sizes of the particles.
2. The nature and quality of the coal as determined by the source from which it is obtained.
3. The temperature and duration of carbonization.
4. The blending of different types of coal with one another and with coke in various proportions.

5. The effect of briquetting with and without a binder.
6. The nature of the inorganic constituents of the coal.

The efficient blending of different types of coal with one another and with coke in various proportions cannot be accomplished without the preliminary disintegration of the ingredients to reduce the particles to relatively small sizes. The first step in the investigation is, therefore, to determine the variations in the yields and qualities of the products obtained when particular coals in graded sizes of particles are carbonized under the same conditions.

When any investigation of the influences of various conditions of operation of a process is undertaken, one factor at a time should be studied by maintaining all other factors constant, and submitting only the one under consideration to variation in different experiments. In some instances, the resulting changes may be comparatively small, so that the most accurate control attainable of all factors is of prime importance if reliable information is to be obtained. It may be contended that in a study of the carbonization of coal, the experiments should be conducted in a carbonization unit built on a commercial scale. In the first place, the selection of the plant would not be a simple matter, since commercial units are not of standard size and design, but vary considerably. Secondly, the time required for the investigation of the fundamentals would be prohibitively great. Each individual experiment would occupy a period of several days or weeks, quite apart from the preliminary work of selecting and preparing the coal in the condition required for the experiment. Further, the number of experiments involved is considerable. For example, if six types of coal are examined in five grades of sizes, under only one set of conditions, a minimum of thirty experiments is necessitated, or sixty experiments if each is carried out in duplicate. In addition to the actual experiments, preliminary trials are necessary to ensure that the operation of the plant is satisfactory and that the measurements can be obtained with the required degree of accuracy. From these considerations, the large amount of time which would be occupied in a study of the six factors already enumerated—and there are other factors—can readily be appreciated.

The difficulties to be encountered in obtaining accurate data in certain directions from experiments conducted with a commercial unit are not easily surmounted. For example, retorts made of the usual refractory materials are to some extent porous and are liable to develop cracks, so that there is always some leakage of gas into or out of the retort. If data for the total yield and quality of the gas and the rates of gas production are desired, it is consequently essential that the retort should be made of material which is perfectly gas-tight.

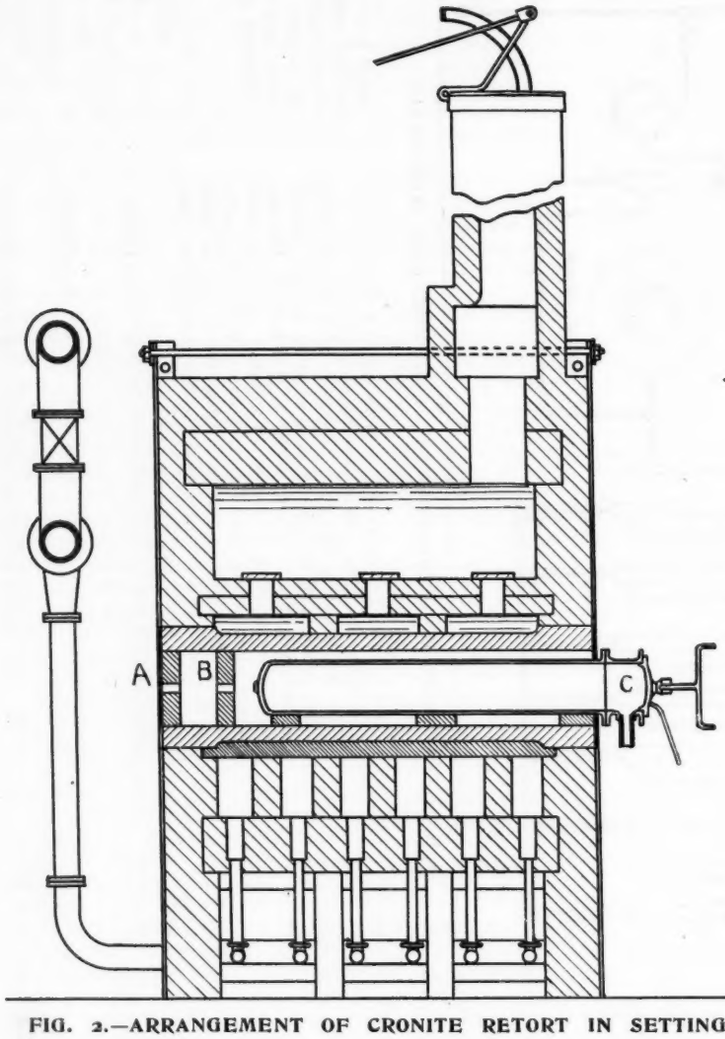


FIG. 2.—ARRANGEMENT OF CRONITE RETORT IN SETTING.

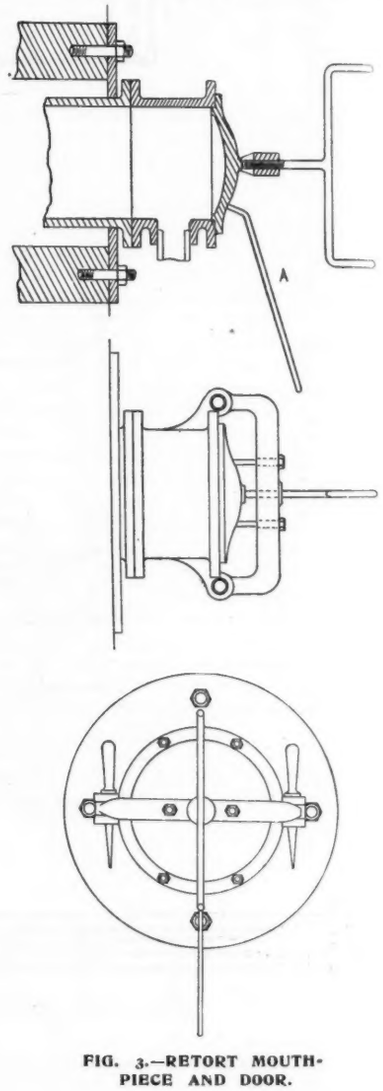


FIG. 3.—RETORT MOUTHPIECE AND DOOR.

The usual small-scale laboratory apparatus in which a very small quantity of coal, ranging from a few ounces to two or three pounds, is carbonized, also suffers certain disadvantages. The apparatus can readily be made gas-tight, the conditions may be accurately controlled, and each experiment can be completed in a comparatively short time; but the amounts of some of the products collected are too small to enable satisfactory samples for examination to be obtained. The results, especially in connection with the yield and quality of the tar, may therefore be of little value. Further, a laboratory apparatus capable of carbonizing only about 2 lbs. of coal per charge cannot satisfactorily be employed to determine the influence of size of particles except with grades of small sizes. The internal

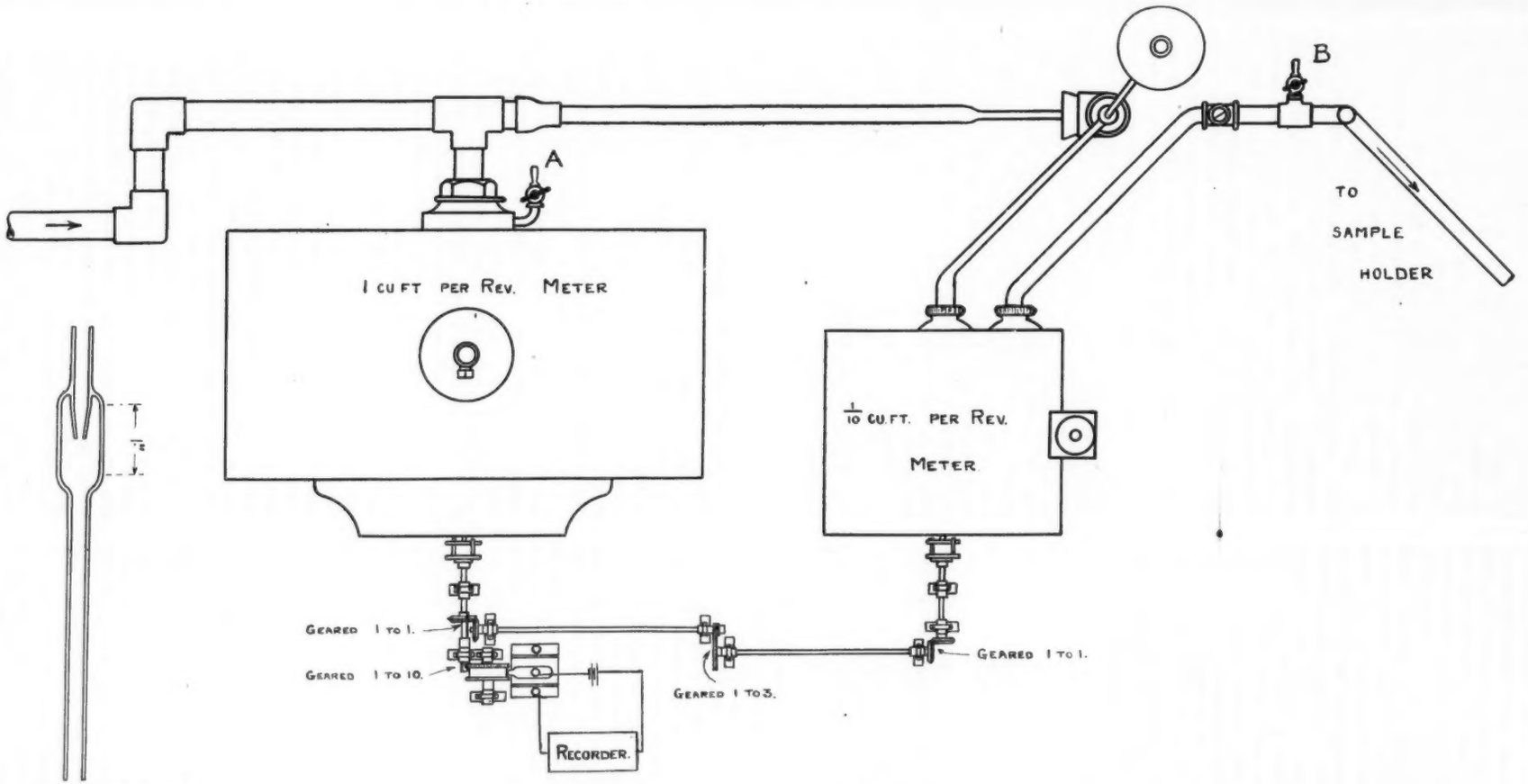


FIG. 4.—REGULATING JET FOR CIRCULATING LIQUIDS.

FIG. 5.—ARRANGEMENT OF GAS METERS.

volume of the condensing and purifying system in some types of laboratory apparatus is also too great in comparison with the volume of gas and amount of tar produced from a single charge of coal.

It is evident, therefore, that the apparatus employed must be designed to enable all conditions of operation to be controlled with accuracy. At the same time, the apparatus must be small enough to allow of individual experiments being carried out in a reasonable time. The retort must be made of a material which will not only withstand high temperature, but will also remain gas-tight. Further, the internal volume of the condensing, purifying, and measuring apparatus should be as small as possible relative to the quantities of products produced during the carbonization of a single charge of coal, in order that preliminary experiments to ensure the correct quality of gaseous and liquid products in the apparatus may be reduced to a minimum. On the other hand, the carbonization unit should be large enough to ensure that the quantity of each product is sufficient for the purposes of examination as regards quality.

Another point to be remembered is that the larger the carbonization unit, the more probable it is that the results obtained will approximate to those procurable in a commercial plant.

When the fundamentals have been investigated in a small experimental plant, then, from the results obtained, the factors of greatest importance may be selected and subjected to further examination in a full-sized commercial plant.

With the various requirements in view, the research staff designed and erected the experimental plant hereinafter described.

EXPERIMENTAL PLANT.

The general arrangement of the experimental plant is shown diagrammatically in fig. 1. The plant includes a horizontal retort closed at one end, condensers, ammonia scrubbers, purifiers, gas meters and a gas-sample holder.

Retort.—In the first instance, several types of coal test retort were inspected; and as far as possible, information was obtained on such points as cost, useful working life, and the maximum temperature which each material would withstand in practice. As a result of these inquiries, it was decided that the material which would probably most nearly meet the requirements would be an alloy consisting mainly of nickel and chromium. Retorts of a similar material are in use at several gas-works for the purpose of testing small samples of about 2 lbs. of coal; and results obtained in a nickel-chromium alloy retort were described in June, 1922, in a paper presented by Dr. G. Weyman to the Institution of Gas Engineers.

The retort of the experimental plant described in this report was made by the Cronite Foundry Company, Ltd., of Tottenham, who have kindly supplied the following analysis to represent the approximate composition of the particular alloy from which the retort was cast.

	P.Ct.
Nickel	67
Chromium	16·5
Iron	12·5
Tungsten	2·25
Manganese	trace
Silicon	trace

Although the retort, which is probably the largest yet made from this alloy for use in the carbonization of coal, has been maintained at temperatures of about 1000° C. for more than 2000 hours, it does not show any signs of deterioration, and is still perfectly gas-tight.

The retort, which is of circular cross-section and closed at one end, is 8 in. in internal diameter, 4 ft. 9 in. in length, and the thickness of the metal is ½ in.; the open end is provided with a flange of an overall diameter of 12 in. The retort is supported on pieces of firebrick in such manner that it rests centrally within a circular fireclay retort as shown in fig. 2. The internal diameter of the fireclay retort is 12 in., so that an annular space of 1½ in. surrounds the metal and separates it from the fireclay. Between the closed end of the cronite retort and the outer wall of the setting, two circular blocks of firebrick, each 3 in. in thickness and 11½ in. in diameter, are placed in the positions A and B (fig. 2), with the object of reducing the losses of heat by radiation from the closed end. The fireclay retort is closed at the one end by an iron disc of 20 in. diameter and ¾ in. thickness; and the annular space at the other end is closed by means of an iron ring which fits over the cronite retort, as shown in fig. 3. Both the iron disc and the ring are bolted to the fireclay retort, and the joints are packed with asbestos and fireclay cement. The cronite retort is placed within the fireclay retort with the object of ensuring that the metal retort can be raised to a uniform temperature throughout a sufficient length, and to prevent any deterioration of the alloy which might result from direct contact with the heating gases.

Retort Mouthpiece.—The construction of the retort mouthpiece, denoted by C in fig. 2, is shown in further detail in fig. 3. It is made of cast iron and is 8 in. in internal diameter and 6 in. in length. The mouthpiece is closed by a circular cast-iron door provided with a flange which serves to hold an asbestos ring washer of ⅛ in. thickness, 7¾ in. inner diameter and 9¾ in. outer diameter. Two studs, each ⅜ in. in diameter, are screwed into the retort door and fit loosely into two holes drilled in a cast-iron bracket, which hinges by loose pins passing through two lugs cast on the side of the mouthpiece. A threaded pin with lever handle passes through the centre of the bracket. By operation of the lever handle, the door is forced up and held tight against the faced end of the mouthpiece. The retort is opened by unscrewing the lever handle, removing one of the hinge pins, and swinging the door back on the second pin. The bent handle A (fig. 3) fastened to the door of the retort serves to guide the door into its correct position during the closing of the retort; and the hinge pins are tapered at the ends to enable them to be pushed rapidly into position.

Heating of Setting.—The retort setting, shown in section in fig. 2, is heated by means of six burners supplied with town gas and with air from a compressor. The amounts of gas and air for each burner are controlled by separate cocks, and the two gases enter a mixing chamber before travelling upwards to the burner nozzle. The air compressor is belt driven at a constant speed from a shaft operated by an alternating current electric motor. From the compressor the air enters a reservoir provided with weighted escape valve and a gauge to enable the pressure to be regulated to the required amount. When the heating of the setting has been adjusted to maintain the cronite retort at the desired temperature, no difficulty is experienced in retaining at a constant value the pressure of the air supply to the burners. A number of preliminary carbonization trials emphasized the importance of being able accurately to control the heating of the retort, and proved that in order to repeat the experimental results with the degree of agreement desirable, the temperature of the cronite retort must not differ by more than 10° C. in duplicate experiments at approximately 1000° C. This accurate control of temperature necessitates the town gas supply to the burners being maintained at a pressure as uniform as possible throughout day and night. For this purpose, a Stott's mercury governor was fixed in the gas supply service; and a pressure recorder was installed to register the pressure at a definite point in the gas main between the governor and the burners. The governor is adjusted to give a convenient pressure lower than the minimum reached in the gas main at the inlet to the governor at any time during the day or night. The mercury governor has proved satisfactory; the pressure recorder charts showing a maximum fluctuation of less than one-tenth inch water gauge throughout the twenty-four hours.

Gas Offtake.—The mouthpiece of the retort is provided with a gas offtake situated as shown in fig. 1. According to this arrangement, the products of distillation leave the retort by a short descension pipe, and then pass upwards through an ascension pipe, about 5 ft. in length, before entering the condenser. At a distance of 2 ft. from the lower end of the ascension pipe, a plug cock Q is inserted so that the retort may be isolated from the condensing and purifying apparatus during the removal of coke. At this point, the diameter of the ascension pipe is reduced from 2 in. to 1½ in. The object in removing the distillation products from the bottom of the mouthpiece of the retort is to prevent any condensates from running back into the retort and thereby undergoing further decomposition. The ascension pipe following the gas offtake is arranged to prevent pitch from being carried forward into the condensers. Pitch is deposited in the crosses immediately below the retort mouthpiece, but this deposit is readily removed when the retort is opened for discharging.

Condensers.—From the top of the ascension pipe, the distillation products travel through a length of 9 ft. of pipe, 1½ in. in diameter (shown broken in fig. 1), placed at a gradient of one in eight. This pipe is cooled over a length of 6 ft. by means of a water spray supplied from a service of ¾ in. diameter with holes of ⅛ in. diameter drilled at intervals of 2 in. A channel placed below the condenser serves to carry away the water from the spray. From this first water-cooled condenser, the products of distillation travel vertically downwards by way of the pipe A, fig. 1, before passing through the second and third water-cooled condensers B and C. Each of the second and third condensers consists of about 6 ft. of vertical pipe of 1½ in. diameter, surrounded by a metal tube fitted into a diminishing socket, as shown in fig. 1. The outer tubes are supplied with cooling water which enters at D and travels in series through the condensers to the outlet E. The cooling water thus travels in the direction the reverse of that taken by the gas. The tar and liquor which separate out in the three condensers flow into the seals F and G, from which they overflow through side branches into receptacles provided for the purpose.

Ammonia Scrubber.—After leaving the third condenser, the gas passes upwards through a short length of pipe (H, fig. 1) 1½ in. in diameter, filled with glass marbles each approximately ⅝ in. in diameter. The marbles are prevented from entering and blocking the lower side limb, by means of a spiral of iron wire. The object of this short length of pipe is to remove tar fog before the gas

enters the ammonia scrubber by way of a connection of 1 in. in diameter.

Each of the scrubbers J and K is 2 ft. 6 in. long, 2 in. in diameter, and filled with approximately 250 glass marbles. These scrubbers and side limbs are made of lead, and the joints are lead-welded. The ammonia remaining in the gas is removed in the first scrubber, J, by washing with a dilute solution of sulphuric acid supplied by gravity from a glass aspirator bottle. The rate of supply of acid solution is controlled by a glass jet, placed in the connection between the aspirator bottle and the scrubber, and constructed as shown in fig. 4. The acid solution flows through the scrubber into a seal, from which it overflows into another aspirator bottle. Periodically the solution collected in the lower bottle is returned to the aspirator bottle at the top, so that a continuous circulation of acid solution is maintained. The second scrubber, K, is of the same design and dimensions as the first scrubber, and is operated in a similar manner; but it is supplied with water with the object of removing any acid solution which might otherwise be carried forward to the purifiers.

The ammonia scrubber and seals must be made of some material which is not destroyed by any interaction with a solution of sulphuric acid; and that is the reason lead was chosen.

Purifiers.—The sulphuretted hydrogen in the crude gas is removed by a 15 p.ct. aqueous solution of caustic soda, circulated through the purifiers L and M. These purifiers are made of iron pipes each 2 ft. 6 in. in length and 2 in. in diameter, and filled with glass marbles. The caustic soda solution is supplied from glass aspirator bottles and is circulated by the same procedure as that already described for the aqueous solution of sulphuric acid in the ammonia scrubber. The final scrubber, N, which is of the same design and dimensions as the purifiers, is supplied with water for the purpose of removing any caustic soda solution. A 1 in. plug cock is provided at the position, O; and the connections to the gas meters are so placed in the actual plant that any condensates drain down to the small cock situated at P.

Gas Meters.—The purified gas is measured in two meters, arranged in parallel. The major portion of the gas travels through a wet meter of the type usually employed in testing large meters to be used in town supply. The remainder of the gas first travels through a small purifier, in which any sulphuretted hydrogen not taken out in the main purifiers is removed by caustic soda solution. This gas is then measured in a small meter and is collected in a test holder of 11 c.ft. capacity.

Internal Volume of Plant.—The internal volume of the experimental apparatus should be as small as possible relative to the quantities of products obtained from a single charge of coal. The condensing, purifying, and measuring apparatus could not have been made smaller without causing an excessive pressure in the system during the early stages of carbonization at high temperatures, when the rate of evolution of products is at a maximum. The use of sulphuric acid for the removal of ammonia and of caustic soda for sulphuretted hydrogen has enabled the internal volumes of the scrubbers and purifiers to be made very much smaller than would have been possible if the ammonia had been taken out by washing with water, and the purification had been effected by means of iron oxide. The gas measuring apparatus is of the minimum size consistent with accurate measurement when the rate of gas evolution is at a maximum. From the sample meter the purified gas enters the test holder by way of a ½-in. service, which reaches almost to the top of the dome in the centre of the holder bell when the latter is in its lowest position. At the commencement of each experiment, the bell is filled with water to within an inch of the top of the gas inlet, so that in the first instance the gas space in the sample holder consists of a depth of not more than 2 in. in the small dome of the bell. The diameter of the dome is 7 in. A depth of 2 in. therefore represents only about 0·04 c.ft. From the dimensions given, it can be calculated that the total free space in the whole of the apparatus is not more than 4 c.ft., or about 2·5 p.ct. of the volume of purified gas, 160 c.ft., resulting from the carbonization of a single charge of coal under the conditions of the experiments described in this report.

Preparation of Coal.

Grading.—It was decided that attention should be given to measurements of the rates of carbonization as indicated by the rates of gas production; and in view of the importance of the subject, the influence of size of coal particles on the structure and properties of the coke produced, seemed to warrant special consideration.

The gas coal selected for the first set of experiments was obtained from Nottinghamshire. This coal is of moderate coking properties; and when carbonized in full-scale horizontal retorts, the yields of products per ton of coal as charged with 5 p.ct. moisture and 7 p.ct. ash may be represented approximately as follows:

Yields per Ton of Coal as Charged.

Horizontal Retorts.

Gas, therms	70
Calorific value of gas, B.Th.U. (gross) per c.ft.	560
Coke (dry) made, cwt.	12·2
Tar, gallons	12·7

It was necessary to prepare about 2 cwt. of each desired grade of size in such manner that the amounts of moisture and of ash should be as nearly as possible the same in all sizes. The following six grades of sizes were prepared for preliminary trials: 1¼ in. to ¾ in., ¾ in. to ½ in., ½ in. to ¼ in., ¼ in. to 10 mesh, 10 mesh to 30 mesh, and all through 30 mesh.

According to the method adopted for grading the coal, a large quantity, taken from the stack, was screened by means of the 10-mesh riddle. The fines were rejected, and during this first screening any pieces of foreign matter observed were thrown out. The coal freed from the fines was then screened through the 1¼-in. riddle. The pieces larger than 1¼ in. were broken down by gentle treatment with a hand hammer, and the fines produced below 10 mesh were again rejected. The whole of the material between 1¼ in. and 10 mesh was then graded into the first four sizes mentioned. The grades 10 to 30 mesh and through 30 mesh were obtained by the mechanical crushing and hand screening of the grades of larger sizes.

This method of cleaning and grading proved to be satisfactory, as may be seen from Table VIII., in which are given the results of analyses of average samples of the different grades of coal. The procedure adopted resulted in an appreciable reduction in the ash content of the coal, for the percentages of ash in the largest and smallest grades of sizes were respectively 6·1 and 4·4, and the four intermediate sizes contained amounts of ash ranging between 5 p.ct. and 5·2 p.ct., all determined on dried samples, as compared with 8·6 p.ct. in a dried sample of the coal as delivered. The amounts of moisture in the different grades, as prepared, ranged between 5 and 6 p.ct.

Measurements and Weighings.

Coal and Coke.—The amount of coal for each charge, usually 30 lbs., is weighed out from a storage bin and placed in a charging scoop. When the desired period of carbonization has been completed, the hot coke is quenched with water as it is discharged from the retort, and precautions are taken to avoid over-quenching. The cooled coke is air dried before being weighed.

Tar and Liquor.—The condensers of the plant are allowed to drain after the completion of each experiment before the contents of the condenser seals are emptied into the tar and liquor collecting vessels. The tar and liquor are separated from one another, and the measured volume of liquor is corrected for the amounts of water placed in the seals at the commencement of the experiment. The volume of liquor contained in the tar is obtained from the results of distillation tests in which the whole of the tar recovered is treated. The amount of dehydrated tar is weighed, and the volume is calculated from the specific gravity.

Pitch.—The amounts of pitch periodically removed from the gas offtake of the retort are added together, and the total weight is obtained for a large number of experiments. From this total weight the average amount is calculated on the assumption that the same weight is deposited in each experiment.

Gas.—The make of purified gas is measured by means of the two meters arranged in parallel as shown diagrammatically in fig. 1. The larger meter has a capacity of

1 c.ft. per revolution, and the corresponding capacity of the smaller meter is $\frac{1}{10}$ c.ft. The two meters are connected to one another by means of shafting and gearing, as shown in detail in fig. 5, so that the drum of the larger meter makes three revolutions and passes 3 c.ft. during the time that the smaller meter makes one revolution and passes $\frac{1}{10}$ c.ft. The volume ratio 30 to 1 must remain constant for all rates of gas production. The meters are calibrated periodically with the gas connections arranged in parallel and the inter-connecting gearing engaged. During each experiment, readings are taken at intervals of five minutes for the first fifteen minutes; and for the remainder of the period of carbonization readings are taken at intervals of fifteen minutes.

In addition to the observed meter readings, a chart record to show the rate of gas production is taken automatically. From the spindle (fig. 5) connected by loose coupling to the centre spindle of the drum of the large meter, an ebonite commutator is driven by means of wheels geared in the ratio one to ten. The commutator thus makes one complete revolution for every 10 c.ft. of gas passed through the large meter. At one definite position in each complete revolution, a thin strip of metal on the ebonite wheel comes into light contact with a flat copper spring, and completes an electrical circuit in which a small bell magnet operated by the current from a 4-volt accumulator is placed. When the circuit is completed, the magnet moves an inked pen, operating on a moving chart, a distance of about $\frac{1}{10}$ in. By clockwork mechanism, the chart is made to travel vertically downwards at a constant rate. When the magnet is out of circuit, the pen traces a vertical straight line on the chart, but when the circuit is completed the pen moves to the left, and traces a short horizontal mark. The recording apparatus thus serves to mark the time occupied in the passage of each 10 c.ft. of gas through the large meter, or a total of each 10·33 c.ft. through the two meters. From measurements of the distance betwen the horizontal lines recorded on the chart, data can be obtained to enable curves showing the rates of gas production to be constructed. A reproduction of one of the charts obtained on the recorder, which has been specially designed and constructed by the research staff, is given in fig. 6. The increasing distances between the horizontal or 10 c.ft. marks as time progresses show the falling-off in the rate of gas production as carbonization proceeds.

SAMPLING AND ANALYSIS.

Coal.—When each grade of coal has been prepared in the required quantity, the whole amount is mixed on a large sampling plate and quartered-down. The operation of quartering, without crushing, is continued until a sample of about 20 lbs. is obtained. This sample is then crushed and quartered-down until it is reduced in amount to about 1 lb. The small sample is afterwards ground to a fine powder and used for the purpose of proximate and ultimate analyses and the determination of calorific values according to the methods described in previous reports.

The caking index of the sample of each grade of coal is determined in the following manner. A mixture of dried coal, ground to pass a 90 mesh sieve, and previously ignited fine white Calais sand, graded 60 to 90 mesh, is heated in a platinum crucible for seven minutes, according to the method adopted in the determination of volatile matter. The weight of mixture taken in each experiment is 4 grammes, and the proportion of coal to sand is altered in different experiments. The caking index represents the maximum number of parts of sand which may be mixed with one part by weight of coal to produce a coherent coke as tested by means of a 200 gramme weight. The mixture to be heated in the platinum crucible is covered with a layer of 0·5 gramme of powdered coke, to minimize oxidation. The caking index of cane sugar as tested by this method is 28, and a good coking coal would give values of from 25 to 30.

A sample is also taken as the amounts required for each experiment are weighed out for charging into the retort. This sample is used only for the determination of the moisture content of the coal at the time of charging.

Coke.—The coke produced is sampled immediately after being weighed by crushing and quartering until a sample of about 1 lb. is obtained. This sample is afterwards ground to a fine powder and used for the purpose of proximate and ultimate analyses and the determination of calorific values and true specific gravity.

The coke from certain charges of each grade of coal is reserved for the preparation of sections, the determination of apparent specific gravities, and for any other purposes for which it cannot be used in a crushed form.

The true specific gravity of the coke material is determined in the following manner. The coke is ground to pass a sieve (I.M.M. pattern) of 200 meshes to the inch. A weighed quantity of between 1 and 2 grammes of the dried powder is then exhausted under water in a specific gravity bottle heated to 75° C. in a water bath. The exhaustion is continued for half-an-hour, when the bottle is disconnected and the specific gravity determined in the usual manner.

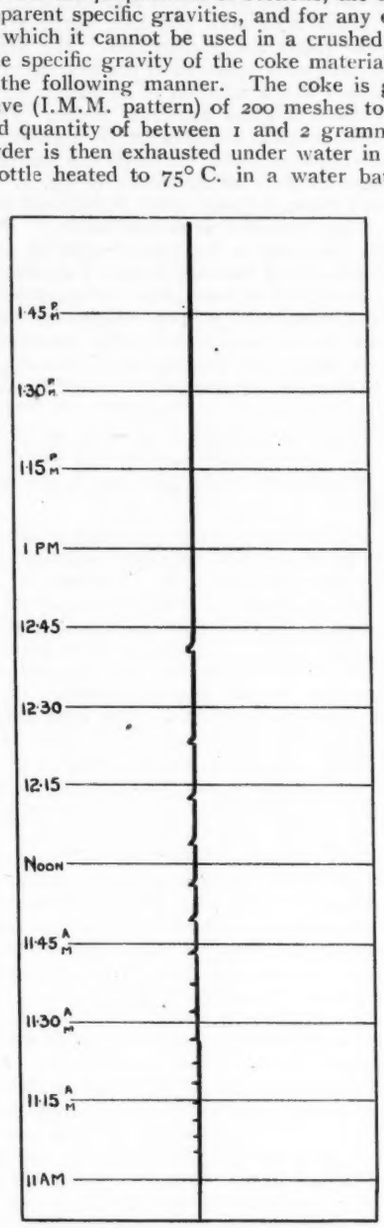


FIG. 6.—GAS RATE RECORDER CHART.

The apparent specific gravity is determined by weighing pieces of coke of size approximating to a half-inch cube, first in air and then under mercury.

Tar.—The tar collected in each experiment is dehydrated by distillation, and the quantity of water obtained is separated and measured. The dehydrated tar and light oil are mixed and weighed; and a small sample is retained for the purpose of ultimate analysis and the determination of calorific value, free carbon, and specific gravity. The whole of the remaining dehydrated tar is then distilled from a cylindrical iron still of the design and dimensions shown in fig. 7. The cover of the still is held gas-tight in position by placing it in a lute containing molten solder, which is afterwards allowed to solidify. It is consequently only necessary to remove the cover for the purpose of recovering the pitch and cleaning the still. A bell-shaped dome is welded inside the cover, and this serves to prevent tar from frothing over into the solder lute. The dehydrated tar is distilled to produce a medium-soft pitch, and the distillate is divided into three fractions:

(*a*) Below 170° C., (*b*) 170° C. to 270° C., and (*c*) above 270° C.

The percentage of free carbon in the dehydrated tar is determined by the extraction of a weighed quantity of 5 grammes in a previously dried and weighed soxhlet thimble in a soxhlet extraction apparatus. The solvent used consists of a mixture of 90 parts by volume of benzene, 5 parts of toluene, and 5 parts of xylene. This mixture is approximately equivalent to benzole of commercial 90 p.ct. grade. The amount of naphthalene in the dehydrated tar is determined by the method described in the pamphlet "General Directions and Specifications relating to the Tar Treatment of Roads," issued in 1923 by the Roads Department of the Ministry of Transport.

The pitch remaining after the distillation of the dehydrated tar is weighed, and samples are taken for the determination of specific gravity and softening-point. The method adopted for the determination of softening-point is that described by Spielmann and Petrie (J.S.C.I., 1919, 38, 69 T.).

Liquor.—The liquor collected from the condensers in each experiment is sampled immediately after being measured. The specific gravity of the sample is taken, and determinations of the ammonia content are made by distillation in the usual manner.

Pitch.—The quantities of pitch removed from the gas offtake are collected together, crushed, and quartered-down until a sample of about 1 lb. is obtained. This sample is used for the purpose of ultimate analysis and the determination of calorific value.

Crude Gas.—At the end of each experiment, the acid solution and water are drained off from the scrubbers and collected from the aspirator bottles used for circulation; and the scrubbers are washed through several times with water. The liquids circulated through the scrubbers and the final washings are added together, agitated, and measured. A sample is taken and used for the determination of ammonia by distillation after making alkaline with caustic soda according to the usual method. The total ammonia produced during the carbonization is obtained by adding together the amount of ammonia contained in the liquor collected from the condensers, and the amount removed in the scrubbers.

The sulphuretted hydrogen contained in the crude gas is taken out in the two purifiers through which a 15 p.ct. solution of caustic soda is circulated. A final scrubber supplied with water serves to remove any caustic soda which may be carried forward from the purifiers. At the end of each experiment the alkaline solution and water are drained off from the purifiers and final scrubber, and collected from the aspirator bottles; and this section of the plant is washed through several times with water. The solutions and washings are added together, stirred, and measured; and a sample is taken. The sulphuretted hydrogen taken out in the purifiers is determined in the following manner:

(*a*) A measured amount of the sample of caustic soda liquor, usually 10 c.c., is run into a measured quantity (50 c.c.) of decinormal iodine solution, to which sufficient hydrochloric acid has been added to acidify the liquor. The excess iodine is titrated with a decinormal solution of sodium thiosulphate, using starch solution as an indicator.

(*b*) A blank determination is made by first adding an excess of a solution of cadmium acetate to a measured amount (10 c.c.) of the sample of caustic soda liquor. The solution is filtered, and the filtrate and washings are added to a measured volume (10 c.c.) of decinormal iodine solution acidified with hydrochloric acid. The excess iodine is determined by titration with standard sodium thiosulphate.

The difference in the amounts of iodine used in (*a*) and (*b*) corresponds with the quantity of sulphuretted hydrogen removed in the caustic soda liquor.

In addition to removing sulphuretted hydrogen, the solution of caustic soda absorbs carbon dioxide from the gas. In order to obtain the volume of purified gas which would pass through the meters if carbon dioxide were not removed, and to make the necessary corrections to the results of analyses and determinations of the calorific value of the gas collected in the sample holder, the volume of the carbon dioxide taken out in the purifiers is ascertained. Solutions made up from commercial caustic soda invariably contain sodium carbonate. A sample representing the composition of the measured volume of alkaline solution placed in the apparatus at the commencement of each experiment, for circulation through the purifiers, is therefore analyzed for content of carbonate by titration with a standard solution of hydrochloric acid by the double indicator method, using phenol phthalein and methyl orange. The quantity of sodium carbonate contained in the sample of caustic liquor collected from the purifiers and final scrubber at the end of each experiment is also determined. For this purpose a measured volume (10 c.c.) of the sample is taken, an excess of a solution of hydrogen peroxide is added to oxidize the sulphide present, and the solution is gently heated for 20 minutes in a flask fitted with a tube containing soda-lime, to prevent absorption of carbon dioxide from the atmosphere. The object of the gentle heating for 20 minutes is to remove the excess of hydrogen peroxide. The solution is cooled and the carbonate present is determined by titration with a normal solution of hydrochloric acid using phenol phthalein and methyl orange as indicators.

The difference in the total amounts of carbonate in the caustic soda liquor at the end of the experiment and at the beginning represents the quantity of carbon dioxide removed from the gas during passage through the purifiers.

Purified Gas.—The make of purified gas is measured by means of two meters arranged in parallel, as shown in fig. 5. The major portion of the gas travels through the larger meter and is carried away to atmosphere, and burnt. The remainder of the gas passes through the smaller meter, and is collected in the gas sample holder.

A truly representative sample of the gas made, therefore, is collected in the test holder. The total volume of gas made in each of the experiments was approximately 320 c.ft., so that the volume of the sample collected was 320 divided by 31, or about 10 c.ft., which amount is sufficient for the purposes of analysis, and determinations of calorific value.

The pressure of the gas at the outlet of the large meter is always equal to that of the atmosphere, and the pressure at the inlet to this meter is never more than a few tenths of an inch (water-gauge) greater than the pressure at the outlet. The pressure at the inlet to the small sample meter is the same as that at the inlet to the large meter, since the connections are arranged in parallel. To ensure that the sample meter functions satisfactorily, the pressure at the outlet should be less than that at the inlet, but by not more than one or two tenths of an inch (water-gauge). The difference in the pressures at the inlet and the outlet of the sample meter is indicated by an inclined pressure gauge connected between the cocks A and B of fig. 5. Since the pressure at the outlet of the sample meter is the same as that in the test holder, it is controlled by suitable adjustment of the weights connected to the holder bell.

The calorific values of the gas collected in the sample holder are determined by means of an improved type of Junkers calorimeter, to which reference is made in the Fourth Report (Trans. Inst. Gas Eng., 1920).

The gas analyses are carried out in a Bone and Wheeler gas analysis apparatus, modified by the addition of two silica bulbs filled with copper oxide. The first silica bulb is heated to 300° C. in a small electric furnace wound with nichrome wire, and is used for the removal of hydrogen. The second bulb, heated to about 850° C., serves for the determination of the volume of methane hydrocarbons of the general formula C_nH_{2n+2}; the value of n in this formula being also ascertained. The various constituents of the gas are determined in the following order.

(1) Carbon dioxide, by absorption in a solution of sodium hydroxide.
(2) Unsaturated hydrocarbons by means of an aqueous solution of bromine.
(3) Oxygen, by an alkaline solution of pyrogallic acid.
(4) Carbon monoxide, by an ammoniacal solution of cuprous chloride.
(5) Hydrogen, by combustion over copper oxide at 300° C.
(6) Methane hydrocarbons, by oxidation with copper oxide at 850° C., and absorption of the carbon dioxide produced.
(7) The residue, nitrogen.

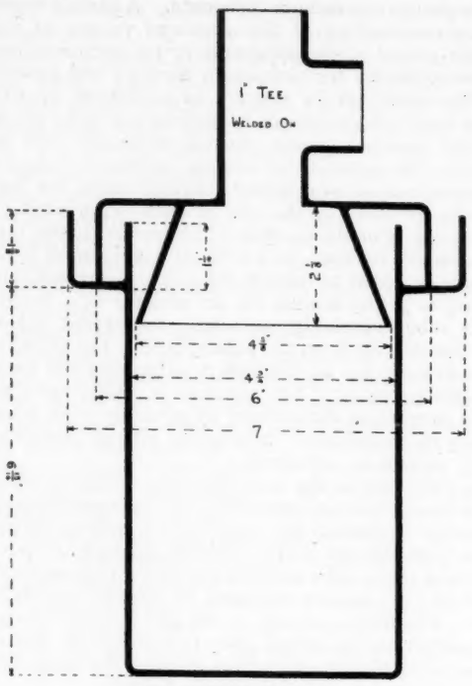


FIG. 7.—TAR STILL.

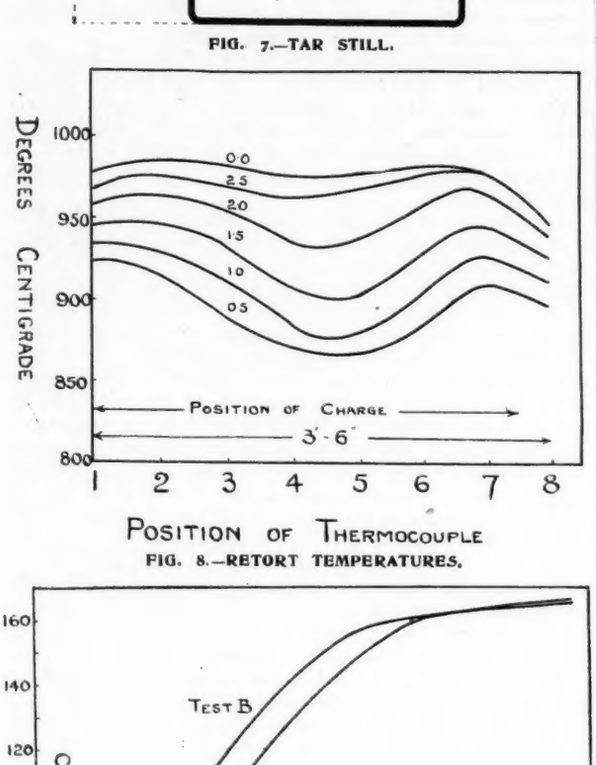


FIG. 8.—RETORT TEMPERATURES.

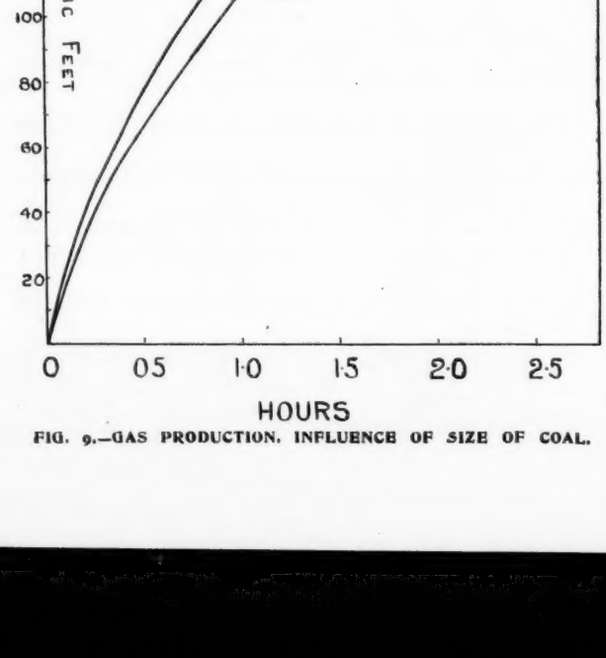


FIG. 9.—GAS PRODUCTION. INFLUENCE OF SIZE OF COAL.

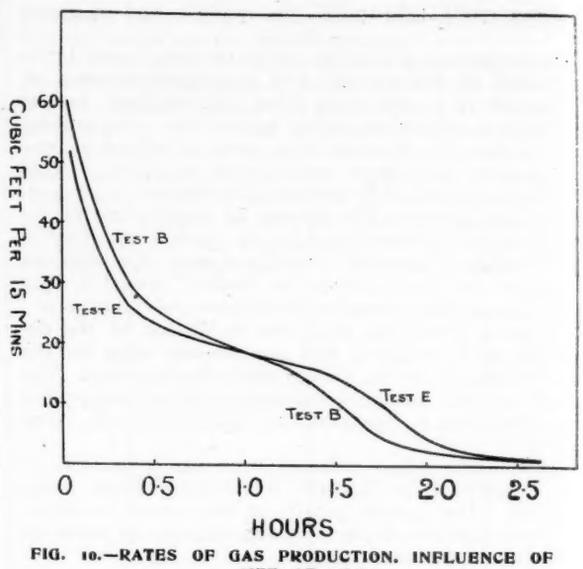


FIG. 10.—RATES OF GAS PRODUCTION. INFLUENCE OF SIZE OF COAL.

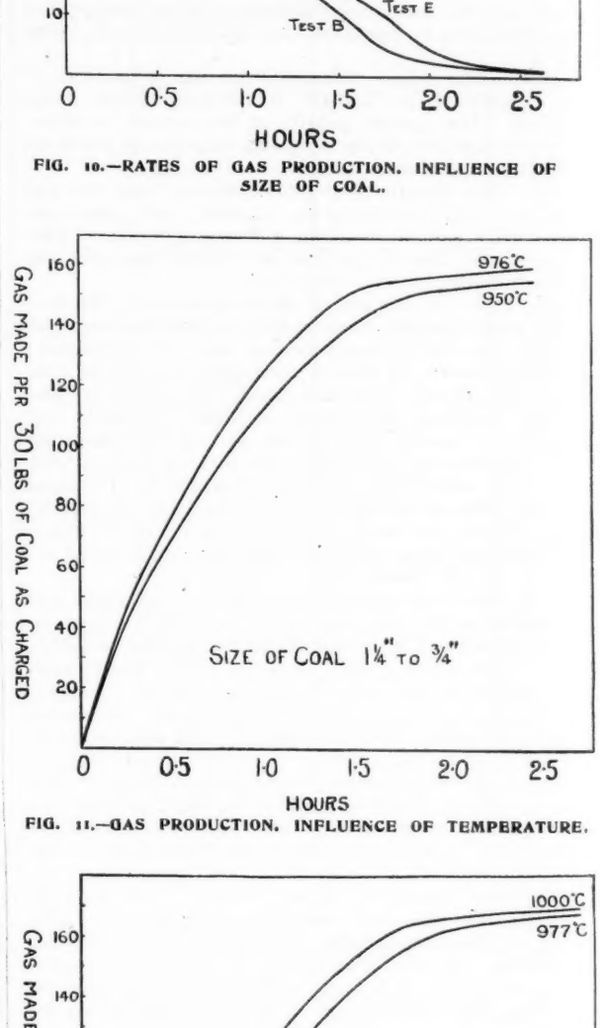


FIG. 11.—GAS PRODUCTION. INFLUENCE OF TEMPERATURE.

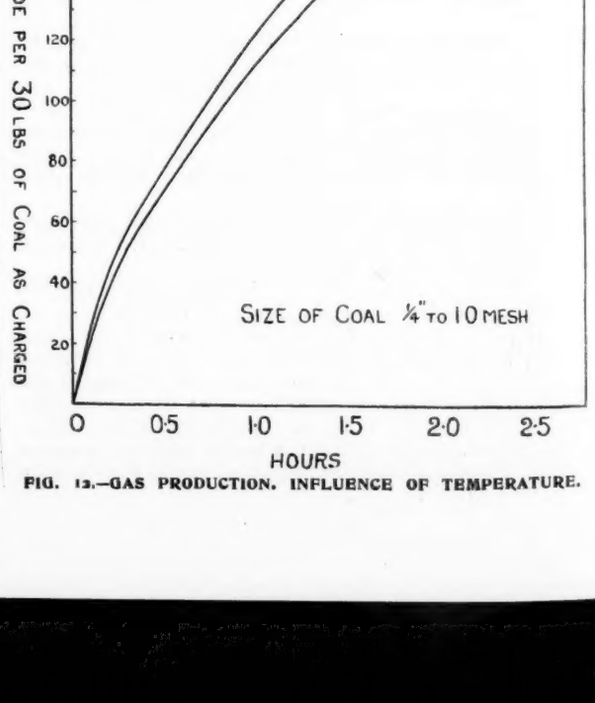


FIG. 12.—GAS PRODUCTION. INFLUENCE OF TEMPERATURE.

The value of n in the methane hydrocarbons of the general formula C_nH_{2n+2} is represented by the inverse ratio of the volume of these hydrocarbons to the volume of carbon dioxide produced from them by combustion over copper oxide at 850° C. A description of the Bone and Wheeler apparatus and the methods of manipulation are given in detail in the Fourth Report.

The composition of the gas obtained by analysis and the determined calorific values are afterwards corrected for the volumes of carbon dioxide absorbed in the main purifiers and in the auxiliary sampler purifier.

Measurements of Temperatures and Pressures.

The temperature of the outside surface of the cronite retort is taken by means of a platinum platinum-rhodium thermocouple placed in the annular space separating the metal and fireclay retorts. The platinum and platinum-rhodium wires constituting the thermocouple are each 6 ft. 6 in. in length, and are insulated from one another by threading through thin silica tubes of about 1 mm. bore. The insulated leads and couple are then placed in a silica sheath closed at one end, 5 ft. 9 in. in length and ½ in. external diameter. The couple is calibrated periodically by measurement of the potentials produced at the known solidifying temperatures of copper (1062° C.), sodium chloride (801° C.), aluminium (657° C.), lead (327° C.), and tin (232° C.). From these measurements a curve is constructed to show the potentials in millivolts produced at different temperatures. The cold junction is made by inserting the ends of the platinum and platinum-rhodium leads in mercury contained in small tubes cooled in water in a thermos flask. The galvanometer is placed in circuit by means of copper leads, the ends of which also dip into the tubes of mercury. The temperature of the cold junction is taken for each calibration point, and the necessary correction is applied.

The temperatures in the annular space are taken on each side of the retort by inserting the sheathed thermocouple through holes drilled in the circular iron plate closing one end of the fireclay retort and through holes cut in the two firebrick blocks, A and B (fig. 2). The temperatures are measured at eight points on each side of the retort. The first point is in line with the closed end of the retort, the eighth point is 3 ft. 6 in. from the closed end, and the intermediate readings are taken at intervals of 6 in. When the setting is being heated up, the supplies of gas and air to the burners are adjusted periodically until the metal retort has attained the desired temperature, and the temperatures recorded are as uniform as possible throughout the distance of 3 ft. 6 in. from the closed end of the retort. The air and gas supplies are then kept constant; and experience has shown that the retort can be maintained at a steady temperature, to within 5° C., provided no coal is charged in. When a carbonization experiment is to be carried out, immediately before the coal is charged in the retort thermocouple readings are taken and an additional weight is placed on the mercury governor in the service supplying the town gas to the burners of the setting. The weight added to the governor increases the pressure of gas by an amount such that the thermocouple readings are the same at the end of the period of carbonization as at the beginning, the increase in the supply of gas to the burners compensating for the heat abstracted by the charge of coal undergoing carbonization. The amount by which the governor must be loaded to satisfy this requirement is determined by experience in preliminary trials. Temperature readings with the thermocouple are also taken at intervals of half-an-hour throughout the period of carbonization. When the experiment is completed, the extra weight added to the gas governor is removed, and the retort is thereby kept at a constant temperature during the preparations for the next experiment.

During the progress of each experiment, readings of the temperature of the gas pasing through the condensing, purifying, and measuring apparatus are taken at regular intervals of fifteen minutes by mercury thermometers placed at (1) the position H (fig. 1) between the condensers and ammonia scrubber, (2) the inlet to the large gas meter, (3) the outlet of the large meter, and (4) the outlet of the gas sample meter. The supply of cooling water to the condensers is adjusted so that the temperature of the gas between the condensers and the ammonia scrubber is kept between 13° and 18°C. (55° and 65° Fahr.). The pressures in the apparatus are also recorded, at regular intervals, at the inlet to the condensers, as indicated by a water gauge connected to the top of the ascension pipe, and at the gas meters.

Methods of Operation of Plant.

When the retort has been raised to the desired temperature, and the conditions required for the particular experiment to be carried out have been established, the condenser seals (F and G, fig. 1) are each filled with a measured quantity of 300 c.c. of water, and the following volumes of liquids for circulation are placed in the aspirator bottles situated above the scrubbers and purifiers: (1) A solution of 200 c.c. of concentrated sulphuric acid in two litres of water for the first scrubber, J; (2) one litre of water for the second scrubber, K; (3) five litres of a 15 p.ct. aqueous solution of caustic soda for each of the purifiers, L and M; (4) one litre of water for the final scrubber, N; and (5) 500 c.c of a 15 p.ct. aqueous solution of caustic soda for the gas sample purifier. The circulation of the liquids through the scrubbers and purifiers is commenced, the water supply to the condensers is turned on, the gas meters are water-lined and their index readings taken, and the gas make recorder is adjusted and set in operation. The desired weight of coal, 30 lbs., is weighed out into a charging scoop made of iron and provided with two handles at one end. The coal is so placed that it occupies a distance of only approximately 3 ft. from the end of the scoop, which is of semi-circular cross-section and 5 ft. 9 in. in length. The diameter of the scoop is such that it just slides easily into the retort. When the coal has been weighed out, the cocks, O, Q, and R (fig. 1) are opened, and the cocks P and S are closed. The charged scoop is then pushed rapidly into the retort, turned over, and withdrawn, and the retort door is closed. The operation of charging the retort occupies only three or four seconds; the door being closed before the appearance of flame.

At the end of the period of carbonization, cocks O and Q are closed, the retort is opened, and the coke is discharged. When the temperature of the retort is approximately 980° C., no difficulty is experienced in discharging the coke produced from the coal used during the experiments described in this report. The coke almost fills the cross-section of the retort, but since some shrinkage from the wall occurs, a metal scoop of the same pattern as that used for inserting the charge of coal can readily be pushed into the retort. The scoop is withdrawn, and about four-fifths of the coke is removed in the first operation. A second operation of the scoop removes nearly the whole of the remaining coke, and the last small quantity is taken out by means of an iron rake. The cocks O and Q are again opened, and a second charge of coal is pushed into the retort. The volumes of circulating liquids supplied to the scrubbers and purifiers are sufficient for the gas produced from two charges or 60 lbs. of coal.

EXPERIMENTAL RESULTS.

A number of preliminary trials were first carried out with charges of coal varying in weight from 29 lbs. to 37 lbs. As a result of these trials it was found that the most satisfactory amount of coal for each individual charge was 30 lbs.

When sufficient experience had been gained in the preliminary trials, tests in which attempts were made to secure the whole of the necessary data were commenced. In the first instance, six complete tests were carried out, each test including two charges of 30 lbs. of coal. The average temperatures recorded by the platinum platinum-rhodium thermocouple immediately before each charge of coal was placed in the retort are given in the following table, in which the grades of sizes of coal are also included.

Preliminary Tests.

Average Temperatures of Retort, ° C.

Test No.	1.	2.	3.	4.	5.	6.
Grade of coal, in.	1½–¾	¾–½	½–¼	¼–10 mesh	1½–¾	1½–¾
First charge of coal	1010	990	985	1015	980	975
Second charge of coal	985	975	970	990	940	955

The figures for the averages of the temperatures recorded immediately before the second charge of coal was placed

in the retort also represent the temperatures of the retort when the period of carbonization, 2¾ hours, of the first charge had been completed. It will be observed from these figures that the temperature at the end of the period of carbonization was in every case lower than at the commencement; the maximum difference being 40° C. in Test 5, and the minimum 15° C. in Tests 2 and 3. The temperature at the end of the carbonization of the second charge in Test 6 was 945° C., showing a difference of 10° C. A survey of the results obtained during these six tests revealed reasonable agreement in Tests 1, 5, and 6 with the same grade of coal, 1¼ in. to ¾ in., as far as yields of coke, tar and ammonia, and gaseous therms were concerned, but it was concluded that the rates of production of gas, as expressed in volume against time, had been influenced too greatly by the differences in temperatures of carbonization to allow reliable conclusions to be drawn regarding the influence of sizes of coal particles. It was after these six tests had been completed that the mercury governor was installed in the gas supply service to the burners of the setting, to enable more accurate control of the temperature of the retort to be obtained.

In the second series of tests, the procedure already described under the heading "Measurements of Temperatures and Pressures" was adopted, and accurate control of all conditions, including the temperature of the retort, was thereby secured. The principal results of these tests, designated A to H, in which different grades of sizes of coal from a maximum 1¼ in. to ¾ in. to a minimum 10 mesh to 30 mesh were carbonized, are set out in Table I. Experiments were also conducted with the smallest grade of coal—namely, all through 30 mesh—but some difficulty was experienced. The charge of coal was readily placed in its correct position in the retort; but as soon as the retort had been closed, the gas evolved pushed the powdered coal forward to the mouthpiece, and blocked the gas offtake.

The figures given for Test A in Table I. represent the results obtained in experiments in which eight charges of coal, each of 30 lbs., were carbonized. The results for each of the Tests B, C, and D, were obtained from the carbonization of four charges of coal, and in each of the Tests E, F, G, and H, two charges of coal were carbonized. The period of carbonization of each charge in the first five Tests A to E, was 2¾ hours, but in the last three Tests, F, G, and H the period was reduced to 2 hours.

The figures given for the temperatures of the retort in the first five tests represent the averages of the temperatures recorded, at the eight points of measurement in the annular space surrounding the cronite retort, at the beginning and end of the period of carbonization of each charge. The weight added at the commencement of each experiment to the mercury governor in the gas supply service to the burners of the setting, was sufficient to ensure that the temperature of the retort would be as nearly as possible the same at the end of a carbonization period of 2¾ hours as at the beginning. The same weight was added to the governor in Tests F, G, and H; but since the period of carbonization was only 2 hours, the average temperature of the retort at the end of this period was lower than at the beginning. The initial and final average temperatures for these three tests, therefore, are given. When the coke produced after carbonization for two hours had been withdrawn, sufficient time was allowed to heat up the retort to the initial temperature before the next charge of coal was inserted The accuracy with which the desired temperature conditions of the retort were obtained is illustrated by the figures given in Table I. for the averages of the temperatures at the commencement of each period of carbonization; these average temperatures range from 974° to 979° C., the maximum difference being only 5° C.

The yields of gas, corrected to the standard conditions of 60° Fahr., 30 in. mercury, and saturated with water vapour, varied from a minimum of 12,120 c.ft. per ton of coal as charged in Test F, in which the period of carbonization was two hours, to a maximum of 12,790 c.ft. in Test D, with a carbonization period of 2¾ hours. The lowest determined gross calorific value of the gas made was 579 B.Th.U. per c.ft. in Test D, and the highest was 600 B.Th.U. per c.ft. in Test E. In general, the thermal value of the gas made, in therms (gross) per ton of coal, rose from 72·3 in Test A with the grade of coal 1¼ in. to ¾ in. to 75·8 therms in Test E with the grade 10 to 30 mesh. A similar increase in gaseous thermal yield with a reduction in the sizes of coal particles may be observed from the results for Tests F, G, and H, though the yields in these three tests are lower than in Tests B, C, and E with the same grades of coal, owing to the shorter period of carbonization. This increase in yield of gaseous therms with decreasing sizes of coal particles would appear to be due largely to an increase in the amount of secondary decomposition of the tar, for it will be observed that in Tests A and E there was a gradual reduction in the yield of tar from 8·3 gallons to 6·2 gallons per ton of coal.

The results of analyses of the purified gas made during the different tests do not show any marked differences in composition. The value of n in the formula C_nH_{2n+2} representing the composition of the methane hydrocarbons was approximately the same in all tests, and averaged 1·04. The methane hydrocarbons may, therefore, be represented by the expression $C_{1\cdot04}H_{4\cdot08}$, which is equivalent to a mixture containing 96 p.ct. of methane and 4 p.ct. of ethane. The amounts of carbon dioxide removed by the solutions of caustic soda circulated in the purifiers have been included in the figures given in Table I. to represent the volume of gas made per ton of coal; and the necessary corrections have been made in arriving at the figures given for the composition and calorific values of the gas.

The specific gravities of the gas made have been calculated from the values of the specific gravities of the individual constituents relative to air at 60° Fahr., 30 in. mercury, and saturated with water vapour.

The yield of dry coke obtained per ton of coal in the eight tests averaged 13·0 cwts.

The total amount of pitch removed from the gas offtakes during a large number of experiments was equivalent to 37 lbs. per ton of coal carbonized. If this pitch be assumed to have a density of 1·3, then 37 lbs. would occupy a volume of approximately 2·8 gallons.

The volume of liquor collected in the condensers averaged 23·5 gallons per ton of coal. The total yield of ammonia contained in the liquor from the condensers, and washed out of the gas by means of sulphuric acid, was equivalent to an average amount of 22·7 lbs. of ammonium sulphate per ton of coal. Of the ammonia removed from the crude gas, approximately 75 p.ct. was contained in the liquor from the condensers and 25 p.ct. was absorbed by the sulphuric acid in the first scrubber.

In the last item of Table I., the amounts of sulphuretted hydrogen contained in the crude gas, expressed in grains per 100 c.ft., are shown. From these figures it will be observed that there was a steady diminution from 640 grains in Test A with 1¼ in. to ¾ in. coal to 430 grains in Test E with the 10 to 30 mesh coal; but in considering these figures the amounts of sulphur in the coal and in the products coke and tar should also be taken into account.

Comparing the results of the tests with those already given under the heading "Preparation of Coal" to represent the yields obtained when Nottinghamshire coal from the same source is carbonized in full-scale horizontal retorts, it will be observed that the yields of gas in therms, and of coke in cwts. are higher in Table I., but that the yields of tar are lower than ordinarily obtained in practice.

RETORT TEMPERATURES.

The averages of the temperatures registered by the platinum platinum-rhodium thermocouple, at the beginning and end of the different periods of carbonization, for each of the eight points of measurement, are set out in Table II. for the first five Tests A to E, in which the time of carbonization was 2¾ hours. The overall averages of the temperature measurements, as given in the first line of Table I. and in the last item of Table II., were obtained by considering the readings at points 1 to 7 to be of equal value, but the readings at point 8 to possess only half of the value of the readings of any one of the first seven points. This method of obtaining the overall averages was adopted since each charge of coal almost filled the cross-section of the retort over the length of 3 ft. represented by the first seven points of temperature measurement; but the front of the charge rested at an angle in the portion of the retort corresponding with the seventh and eighth points of temperature measurement.

TABLE I.—*Results per Ton of Coal as Charged.*

Size of Coal	1½ In. to ¾ In.	¾ In. to ⅜ In.	⅜ In. to ¼ In.	¼ In. to 10 Mesh.	10 to 30 Mesh	¾ In. to ⅜ In.	⅜ In. to ¼ In.	10 to 30 Mesh.
Test	A	B	C	D	E	F	G	H
Temperature of retort, °C.	976	978	978	977	979	974–946	977–959	978–950
Time of carbonization, hours	2·75	2·75	2·75	2·75	2·75	2·0	2·0	2·0
Moisture in coal as charged, p.ct.	5·0	5·1	5·4	5·7	6·0	5 4	5·5	6·0
Ash ,, ,, ,, ,, ,,	5·8	4·8	4·8	4·9	4·7	4 8	4 8	4·7
Gas made per ton of coal, c.ft. (60° Fahr., 30 in.)	12,170	12,520	12,635	12,790	12,640	12,120	12,345	12,375
Composition of gas—volumes p.ct.								
CO_2	2 9	2·9	2·9	3·1	2·9	2 8	2·8	2·6
C_mH_n	4·9	4·8	4·6	4·4	5 0	4·6	4·5	4·6
O_2	0 3	0·2	0·3	0·2	0·3	0·2	0·3	0·3
CO	11·3	11 7	12·0	11·8	11·4	11 8	11·8	11·7
H_2	52·2	52·0	51·0	52·4	51·1	51·2	51 9	51·5
C_nH_{2n+2}	26·1	25·8	26·0	25·8	26·1	26·6	26·0	26·6
N_2	2·3	2·6	3·2	2·3	3·2	2·8	2·7	2·7
	100·0	100 0	100·0	100·0	100·0	100·0	100·0	100·0
Calorific value of gas, B.Th.U. per c.ft. gross	594	590	582	579	600	596	587	599
,, ,, ,, ,, ,, net	534	531	522	519	539	537	527	539
Thermal value of gas per ton of coal, therms gross	72·3	73 9	73·5	74·1	75 8	72·2	72·5	74·1
,, ,, ,, ,, ,, therms net	65·0	66·4	66·0	66·4	68·1	65·1	65·1	66·7
Specific gravity of gas (air = 1)	0·443	0·445	0·452	0·440	0·453	0·447	0·443	0·443
Coke (dry) in cwt. per ton of coal	13·1	13·1	13·0	12·9	12·9	13 0	13·0	13·0
Tar (dehydrated) in gallons per ton of coal	8·3	7·9	7·8	7·3	6·2	7·9	7 8	6·2
Pitch from gas offtakes, lbs. per ton of coal	37	37	37	37	37	37	37	37
Ammonia liquor, gallons per ton of coal	23·2	21·6	23 3	23·6	24·0	22·1	24 8	25·1
Ammonium sulphate, equivalent of ammonia per ton of coal, lbs.	24·8	23·5	24·4	23·5	22 0	20·8	23 3	19·6
Sulphuretted hydrogen, grains per 100 c.ft. gas.	640	530	500	470	430	530	500	430

TABLE II.—*Retort Temperatures, ° C.*

Position of Thermocouple.	Test A.		Test B.		Test C.		Test D.		Test E.	
	Beginning	End.	Beginning.	End.	Beginning.	End.	Beginning.	End.	Beginning.	End.
1	977	969	978	971	978	974	973	968	978	973
2	984	976	985	981	987	982	985	977	985	981
3	981	973	983	977	981	976	982	974	984	977
4	978	972	977	973	980	972	979	969	977	973
5	979	979	980	975	979	978	981	972	980	979
6	982	984	985	987	984	986	989	989	983	987
7	979	983	983	985	973	982	982	987	982	989
8	945	943	949	946	945	943	942	944	952	958
Averages	978	975	980	976	978	977	979	975	980	978
	976		978		978		977		979	

The corresponding retort temperatures for the three Tests F, G, and H, in which the period of carbonization of each charge was only 2 hours, are set out in Table III. The temperatures recorded at the eight points at the commencement of the carbonization periods were as nearly as possible the same in every Test, A to H; but owing to the shorter period of carbonization in Tests F, G, and H, the retort temperatures were lower when the carbonization had been completed than at the beginning. The overall averages given in the last item of Table III. were obtained in the same manner as the corresponding figures in Table II.

The changes which occurred in the temperatures taken as carbonization proceeded are illustrated by the typical set of readings given in Table IV. These readings were obtained during one of the periods of carbonization of a total duration of 2¾ hours. The first line of readings shows the temperatures recorded when the coal was ready for charging into the retort. After the coal had been in the retort for half-an-hour, the minimum temperatures of the series were registered. The temperatures then rose gradually at all points until at the end of 2¾ hours they were approximately the same as at the commencement of the carbonization. The changes which occurred are illustrated by the curves in fig. 8, in which the temperatures are plotted against distances from the closed end of the retort. The length of the retort occupied by the charge of coal and the positions of the thermocouple are also shown. The top curve represents the first set of readings, taken before the coal was charged into the retort; and the other curves represent the readings taken when the carbonization had proceeded for the times indicated in hours by the figures placed above the curves.

RATES OF GAS PRODUCTION.

During the progress of carbonization of each charge of 30 lbs. of coal the readings of the two gas meters were taken at intervals of five minutes for the first fifteen minutes, and at intervals of fifteen minutes for the remainder of the carbonization period. The volumes of gas passed through each of the meters were then corrected to the standard conditions of 60° Fahr. and 30 in. mercury, and from the corrected readings the total volumes of gas made at the different stages of carbonization were obtained. These volumes, given in Table V., represent the amounts of gas which passed through the meters. They do not include the carbon dioxide removed in the purifiers; but since the volumes of carbon dioxide absorbed by caustic soda were approximately the same in all experiments, the figures in Table V. are comparable.

In general, the total volumes of gas made per 30 lbs. of coal as charged increased as the sizes of the particles of coal were reduced; and this general conclusion remains unaltered even when corrections are made for the small differences in the amounts of moisture and ash contained in the coal as charged (*vide* Table I.). When carbonization had proceeded for fifteen minutes, the greatest volume of gas had been obtained from the grade of coal ¾ in. to ½ in., Test B, but at the end of half-an-hour the largest total volume had been evolved by the grade 1¼ in. to ¾ in., Test A, and the volume obtained from the other grades of coal diminished gradually as the sizes of the particles were reduced. The diminution in the total volumes of gas made at any time with reduction in the sizes of coal particles continued until the carbonization had proceeded for 1¼ hours. The rates of gas production then became less with the larger grades than with the smaller grades of sizes, until finally the total volumes of gas evolved from the smaller grades were greater than from the larger grades of coal. The general effect of sizes of particles of coal on the total volumes of gas produced as carbonization proceeded is illustrated by the curves given in fig. 9. These curves have been constructed from the figures in Table V. for Test B (¾ in. to ½ in.) and Test E (10 to 30 mesh) by plotting the total volumes of gas in cubic feet against the times of carbonization. The comparatively

TABLE III.—*Retort Temperatures, ° C.*

Position of Thermocouple.	Test F.		Test G.		Test H.	
	Beginning.	End.	Beginning.	End.	Beginning.	End.
1	979	950	983	963	980	957
2	983	955	984	970	987	964
3	979	943	983	963	982	955
4	971	930	974	947	975	934
5	971	935	973	946	976	931
6	977	954	980	962	980	951
7	975	962	977	969	979	967
8	944	932	949	943	945	941
Averages	974	946	977	959	978	950

TABLE IV.—*Retort Temperatures, °C. Changes with Time of Carbonization.*

Time of Carbonization. Hours.	Position of Thermocouple.							
	1.	2.	3.	4.	5.	6.	7.	8.
0	978	984	982	976	977	982	979	946
0·5	923	916	889	873	867	884	909	896
1·0	934	930	912	886	879	903	927	911
1·5	946	947	934	908	902	927	946	926
2·0	958	963	954	937	937	956	966	939
2·5	968	976	970	963	968	976	978	945

TABLE V.—*Gas Made in C.Ft. per 30 Lbs. of Coal as Charged.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Size of Coal.	1½ In. to ¾ In.	¾ In. to ½ In.	½ In. to ¼ In.	¼ In. to 10 Mesh.	10 to 30 Mesh.	¾ In. to ½ In.	½ In. to ¼ In.	10 to 30 Mesh.
Time of Carbonization. Hrs. Mins.								
0 5	17·1	19·5	20·1	18·7	17·4	18·8	19·7	18·5
0 10	32·4	35·0	34·5	32·9	30 5	34·2	34·2	30 9
0 15	45·5	48·1	46·0	44·4	41 3	46·4	45·9	41·5
0 30	77·6	77·5	74·2	70·3	66·9	75·2	73 6	67·4
0 45	102·8	101·3	95·8	92·2	88·7	98·4	96·3	89·7
1 0	123·4	120·9	115·4	111·6	108·0	117·9	116·0	109·7
1 15	139·5	138·2	132·2	128·6	125·5	134·7	133·2	127·9
1 30	150·3	151·6	146·3	143·8	141·2	147·9	148·1	143·8
1 45	154·7	158·7	157·1	155·8	153·7	156·6	158·3	156·5
2 0	156·9	161·5	161·7	162·8	160·9	160·0	162·4	163·2
2 15	158·4	163·1	163·9	165·6	163·6	..	..	..
2 30	159·5	164·3	165 4	167 2	165·3	..	..	..
2 45	160·5	165·1	166·4	168·3	166·4	..	..	..

TABLE VI.—*Gas Made during each Fifteen Minutes Period.*
[C.Ft. per 30 Lbs. of Coal as Charged.]

Test	A.	B.	C.	D.	E.	F.	G.	H.
Size of Coal.	1½ In. to ¾ In.	¾ In. to ½ In.	½ In. to ¼ In.	¼ In. to 10 Mesh.	10 to 30 Mesh.	¾ In. to ½ In.	½ In. to ¼ In.	10 to 30 Mesh.
Period No.								
1	45·5	48·1	46·0	44·4	41·3	46·4	45·9	41·5
2	32·1	29·4	28·2	25·9	25·6	28·8	27·7	25·9
3	25·2	23·8	21 6	21·9	21·8	23·2	22·7	22·3
4	20·6	19·6	19·6	19·4	19·3	19·5	19 7	20·0
5	16·1	17·3	16 8	17·0	17·5	16 8	17·2	18·2
6	10·8	13·4	14·1	15·2	15 7	13·2	14·9	15·9
7	4·4	7·1	10·8	12·0	12·5	8 7	10·2	12·7
8	2·2	2 8	4·6	7·0	7·2	3·4	4·1	6 7
9	1·5	1 6	2·2	2 8	2·7	..	..	..
10	1·1	1 2	1·5	1·6	1·7	..	..	..
11	1·0	0·8	1·0	1·1	1·1	..	..	..

TABLE VII.—*Gas Made in C.Ft. per 30 Lbs. of Coal as Charged.*

Size of Coal.	1½ In. to ¾ In.		¼ In to 10 Mesh.	
Retort Temperature, °C.	976.	950.	1000.	977.
Time of Carbonization. Hours. Mins.				
0 5	17·1	15·0	22·0	18·7
0 10	32·4	29·0	38·0	32·9
0 15	45·5	40·7	50·8	44·4
0 30	77·6	69·1	77·6	70·3
0 45	102·8	92·2	101·3	92·2
1 0	123·4	111·5	121·8	111·6
1 15	139·5	127·4	139·8	128·6
1 30	150 3	140·2	155 0	143 8
1 45	154·7	148·7	163·7	155·8
2 0	156 9	152·0	166·5	162·8
2 15	158·4	153·8	168·1	165·6
2 30	159·5	155·1	169·1	167·2
2 45	160·5	156·2	169·9	168·3

TABLE VIII.—*Analyses of Coal (Dried Samples).*

Size of Coal.	1½ In. to ¾ In.	¾ In. to ½ In.	½ In. to ¼ In.	¼ In. to 10 Mesh.	10 to 30 Mesh.	Through 30 Mesh.
Test.	A.	B. and F.	C. and G	D.	E. and H.	—
Proximate analysis:						
Vol. matter	36·7	36 7	36·5	36·3	37·2	36·6
Fixed carbon	57·2	58·2	58·4	58·5	57·8	59·0
Ash	6·1	5·1	5·1	5·2	5·0	4·4
	100·0	100·0	100·0	100·0	100·0	100·0
Ultimate analysis:						
Ash	6·1	5·1	5·1	5·2	5·0	4·4
Carbon	76·6	77·8	78·0	77·9	78·3	78·9
Hydrogen	5·0	5·0	5·1	5·1	5·1	5·1
Sulphur	1·7	1·4	1·4	1·6	1·4	1·3
Nitrogen	1·9	1·9	1·9	1·9	1·9	1·9
Oxygen (by difference)	8·7	8·8	8·5	8·3	8·3	8·4
	100·0	100·0	100·0	100·0	100·0	100·0
Calorific value (gross) B.Th.U. per lb.	13,540	13,900	13,780	13,940	13 970	14,240
Caking index	18	18	18	18	18	18

TABLE IX.—*Analyses of Coke (Dried Samples).*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Proximate analysis—								
Volatile matter	2·2	2·4	2·8	2·1	2·0	3·1	3·5	3·4
Fixed carbon	89·0	90·2	89·8	90·3	90·7	89·5	89·1	89·4
Ash	8·8	7·4	7·4	7·6	7·3	7·4	7·4	7·2
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Ultimate analysis—								
Ash	8·8	7·4	7·4	7·6	7·3	7·4	7·4	7·2
Carbon	87·0	89·1	88 6	88 9	89·4	88·7	89·0	89·2
Hydrogen	0·4	0·5	0·4	0·4	0·5	0·6	0·6	0·7
Sulphur	1·3	1 2	1·1	1·1	1·0	1·2	1·1	1·0
Nitrogen	1·8	1·8	1·8	1 8	1 8	1·8	1·8	1·8
Oxygen (by difference)	0·7	0·0	0·7	0·2	0·0	0·3	0·1	0·1
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Calorific value (gross) B.Th.U. per lb.	13,010	13,290	13,130	13,300	13,340	13,190	13,240	13,330
Specific gravity—								
Apparent	0·80	0·82	0·82	0·75	0·75	0·79	0·75	0·75
True (coke material)	1·86	1·84	1·85	1·83	1·83	1·87	1·86	1·86

TABLE X.—*Analyses of Tar (Dehydrated Samples).*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Ultimate analysis—								
Carbon	88·8	88·8	88·6	89·2	89·9	88·6	88 9	90·3
Hydrogen	5·5	5 6	5·3	5 4	5 3	5·4	5·4	5·2
Sulphur	1·0	1·1	1·0	1·0	1·0	1·0	1·0	1·0
Nitrogen	1·3	1·2	1·2	1·3	1·3	1·4	1·4	1·4
Ash	0·1	0·1	0·1	0·1	0 1	0·1	0·1	0·1
Oxygen (by difference)	3·3	3·2	3·8	3·0	2·4	3·5	3·2	2·0
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Calorific value (gross) B.Th.U. per lb.	16,320	16,210	16,120	16,170	16,240	16,040	16, 130	16,150

TABLE XI.—*Distillation Tests of Dehydrated Tar.*

Size of Coal.	1½ In. to ¾ In.	¾ In. to ½ In.	½ In. to ¼ In.	¼ In. to 10 Mesh.	10 to 30 Mesh.
Yield tar, gallons per ton of coal as charged	8·3	7·9	7·8	7·3	6·2
Specific gravity	1·188	1·187	1·185	1·187	1·190
Distillation test, volumes p.ct. —0° to 170° C.	4·0	4·6	5·0	5·2	6·1
170° to 270° C.	28·0	27·0	29·5	28·6	27·0
Pitch.	67·5	66·8	64·3	63·8	66·0
	99·5	98 4	98·8	97·6	99·1
Yield of pitch, weight p.ct.	72·7	72·0	69·5	68·8	71·0
Naphthalene, " "	7	6	8	9	10
Free carbon, " "	16	18	18	17	20

TABLE XII.—*Weight Balances, Lbs. per Ton of Coal as Charged.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Coal	2240	2240	2240	2240	2240	2240	2240	2240
Gas	395	409	419	413	420	397	401	402
Coke	1467	1467	1456	1445	1445	1456	1456	1456
Tar	99	94	92	87	74	94	92	74
Pitch	37	37	37	37	37	37	37	37
Liquor	239	223	240	243	246	227	255	257
Sulphuretted hydrogen	11	9	9	9	8	9	9	8
	2248	2239	2253	2234	2230	2220	2250	2234

TABLE XIII.—*Weight Balances, P.Ct.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Coal	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Gas	17·6	18·3	18·7	18·4	18·7	17·7	17·9	17·9
Coke	65·5	65·5	65·0	64·5	64·5	65·0	65·0	65·0
Tar	4·4	4·2	4·1	3·9	3·3	4·2	4·1	3·3
Pitch	1·7	1·7	1·7	1·7	1·7	1·7	1·7	1·7
Liquor	10·7	9·9	10·7	10·8	11·0	10·1	11·4	11·4
Sulphuretted hydrogen	0·5	0·4	0·4	0·4	0·4	0·4	0·4	0·4
	100·4	100·0	100·6	99·7	99·6	99·1	100·5	99·7

TABLE XIV.—*Carbon Balances. Lbs. per 100 Lbs. of Coal as Charged.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Coal	72·8	73·8	73·8	73·5	73·6	73·6	73·7	73·6
Gas	9·5	9·7	9·8	9·8	9·9	9·5	9·5	9·6
Coke	57·0	58·4	57·6	57·4	57·7	57·7	57·9	58·0
Tar	3·9	3·7	3·6	3·5	3·0	3·7	3·7	3·0
Pitch	1·3	1·3	1·3	1·3	1·3	1·3	1·3	1·3
Liquor	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3
	72·0	73·4	72·6	72·3	72·2	72·5	72·7	72·2

TABLE XV.—*Carbon Balances. P.Ct.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Coal	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Gas	13·0	13·2	13·3	13·3	13·4	12·9	12·9	13·0
Coke	78·3	79·1	78·0	78·1	78·4	78·4	78·5	78·8
Tar	5·4	5·0	4·9	4·8	4·1	5·0	5·0	4·1
Pitch	1·8	1·8	1·8	1·8	1·8	1·8	1·8	1·8
Liquor	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4
	98·9	99·5	98·4	98·4	98·1	98·5	98·6	98·1

TABLE XVI.—*Heat Balances. Therms per Ton of Coal as Charged.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Coal	288·1	295·5	292·0	294·5	294·2	294·5	291·7	294·2
Gas	72·3	73·9	73·5	74·1	75·8	72·2	72·5	74·1
Coke	190·9	195·0	191·2	192·2	192·8	192·0	192·8	194·1
Tar	16·2	15·2	14·8	14·1	12·0	15·1	14·8	12·0
Pitch	5·0	5·0	5·0	5·0	5·0	5·0	5·0	5·0
Sulphuretted hydrogen	0·8	0·7	0·7	0·7	0·6	0·7	0·7	0·6
	285·2	289·8	285·2	286·1	286·2	285·0	285·8	285·8

TABLE XVII.—*Heat Balances. P.Ct.*

Test	A.	B.	C.	D.	E.	F.	G.	H.
Coal	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Gas	25·1	25·0	25·2	25·2	25·8	24·5	24·9	25·2
Coke	66·3	66·0	65·5	65·2	65·5	65·2	66·1	66·0
Tar	5·6	5·2	5·1	4·8	4·1	5·2	5·1	4·1
Pitch	1·7	1·7	1·7	1·7	1·7	1·7	1·7	1·7
Sulphuretted hydrogen	0·3	0·2	0·2	0·2	0·2	0·2	0·2	0·2
	99·0	98·1	97·7	97·1	97·3	96·8	98·0	97·2

sharp bends which occur in the curves at the points when the charges had been in the retort from 1½ to 2 hours appear to indicate that by this time the carbonization zone had penetrated to the centre of the charge. It was due to this observation that the three Tests F, G, and H, with a period of carbonization of 2 hours instead of 2¾ hours, were conducted.

The figures in Table VI. represent the differences in the volumes given in Table V. For example, the volume 32·1 for the second period of fifteen minutes in Test A, is the difference between the figures 45·5 and 77·6 which appear for Test A in Table V. Table VI., therefore, shows the rates of gas production, expressed in volumes of gas evolved during periods of fifteen minutes, at different stages of the carbonization. The highest rates of gas production for the first period of fifteen minutes were obtained in Tests B and F with the ¾ in. to ½ in. grade of coal. In the second and third periods, the largest volumes of gas were evolved in Test A with 1¼ in. to ¾ in. coal, and the volumes gradually decreased with a reduction in the sizes of the coal particles. The volumes of gas evolved during the fourth period were approximately the same with all grades of coal; and in each of the succeeding periods there was an increase in the volume of gas produced from the coal of the largest grade to the smallest grade of sizes. The changes which occurred in the rates of gas production, expressed in terms of cubic feet per fifteen minutes, are illustrated by the curves for Test B (¾ in. to ½ in.) and Test E (10 to 30 mesh) in fig. 10. These curves have been constructed from the figures given in Table VI. combined with data obtained from the charts of the gas rate recorder. The changes in the nature of these curves when the time of carbonization had reached 1½ hours correspond with the comparatively sharp bends in the curves of fig. 9. Another point worthy of notice is that the rate of gas evolution in each test had reached its maximum value within one or two minutes after the retort had been charged.

Typical results of experiments carried out with the object of determining the effect of varying the temperature of carbonization, in the range 950° to 1000° C., are set out in Table VII., in which the figures represent total volumes of gas made as the time of carbonization progressed. The results given for the grade of coal 1¼ in. to ¾ in. were obtained in separate experiments with the retort at 950° and at 976° C.; and in the two experiments with the ¼ in. to 10 mesh grade of coal the temperatures of the retort were 977° and 1000° C. The differences in the results of the two experiments with each grade of coal, therefore, show the effect of an alteration of approximately 25° C. in the retort temperature. The figures in Table VII. are represented graphically in figs. 11 and 12, in which curves of the results for the 1¼ in. to ¾ in. grade and the ¼ in. to 10 mesh grade of coal, respectively, are shown. Comparing these curves with those given in fig. 9 to illustrate the influence of sizes of coal particles, the great importance of accurate control of the temperature of carbonization will be appreciated.

ANALYSES OF COAL, COKE, TAR, AND PITCH.

The results of ultimate and proximate analyses of the different grades of sizes of the coal used are given in Table VIII., in which the gross calorific values as determined in a Mahler bomb calorimeter are also included. The analyses all refer to previously dried samples. In the method adopted in the preparation of the different grades of coal, every effort was made to ensure that each grade would be, as nearly as possible, of the same composition. The success with which this object was achieved is shown by the figures in Table VIII. From the ultimate analyses, it may be seen that the differences in composition of the grades of coal actually used in the tests were small. The percentage of ash in the 1¼ in. to ¾ in. coal (Test A) was about 1 p.ct. higher than in the smaller grades of sizes, and the percentage of carbon was correspondingly lower. The compositions of the four grades of coal used in Tests B to H were approximately the same, the differences being very little more than might be accounted for by experimental errors of analysis and sampling.

The compositions of the coke produced in the tests are given in Table IX. The compositions of the cokes obtained in Tests A to E, in which each charge of coal was carbonized for 2¾ hours, were not widely different from one another. The result of reducing the period of car-

bonization to 2 hours in Tests F, G, and H, may be seen from the percentages of volatile matter given in the proximate analyses, and from the figures for hydrogen in the ultimate analyses. When the period of carbonization was 2¾ hours, the average amount of volatile matter in the coke was 2·3 p.ct. and the hydrogen content averaged 0·44 p.ct.; but when the period of carbonization was reduced to 2 hours, the average amounts of volatile matter and hydrogen were respectively 3·3 p.ct. and 0·63 p.ct.

The figure given for the apparent specific gravity of the coke from each test represents the average of separate determinations of at least ten pieces taken from different parts of the carbonized charge. The specific gravities obtained with different pieces of coke from the same test showed considerable variations. It is therefore only possible to draw the general inference that the apparent gravities of the coke from the smaller grades of coal were lower than from the grades of larger sizes. The true specific gravities, which can be determined with good agreement in duplicate experiments, were approximately the same for the coke obtained in all tests.

The results of ultimate analyses and determinations of the calorific values of samples of dehydrated tar obtained during the tests are given in Table X.; and the averages of the results of distillation tests of the dehydrated tars are set out in Table XI. The ultimate analyses do not show any large differences. The only point that might be noted is that the greatest percentages of carbon and the smallest amounts of oxygen were contained in the tars obtained in Tests E and H with the smallest grade of sizes of coal, 10 to 30 mesh. The yields in tar in these two Tests, E and H, were less than in any of the other tests. The figures from the distillation tests of the tars, Table XI., show a gradual increase in the percentage volume of distillate in the first fraction to 170° C., from 4·0 p.ct. to 6·1 p.ct., as the sizes of the particles of coal carbonized were diminished. At the same time the percentages, by weight, of naphthalene and free carbon gradually increased. These results all lead to the conclusion that a greater amount of secondary decomposition of tar occurred in the experiments with the smaller grades of coal. The specific gravity of the medium soft pitch obtained in the distillation tests was 1·28.

The percentage composition of an average sample of the pitch removed from the gas offtakes of the retort during the tests was as follows: Carbon 79·2, hydrogen 4·1, sulphur 0·9, nitrogen 3·5, ash 3·8, oxygen by difference 8·5. The gross calorific value of this sample was 13,600 B.Th.U. per lb. The high percentage of nitrogen will be observed, but of this amount approximately two-thirds was present in the form of ammonium chloride, which could readily be extracted with water.

Weight Balances.

From the figures given in Table I. to represent the yields of the products obtained per ton of coal carbonized in the Tests A to H, the weight balances set out in Table XII. have been constructed, for the purpose of ascertaining the accuracy with which the tests were carried out. The weights of purified gas produced were obtained from the volumes and specific gravities, and a deduction of 15 lbs. was made in each case to allow for the difference in the weight of air in the apparatus at the commencement and the weight of gas remaining at the end of the experiment. In Table XIII., the weight of coal charged into the retort is taken as 100, and the weights of the products are in proportion, so that the figures represent the weights of the different products as percentages of the weight of coal. The deviations of the totals of the products from 100, therefore, are the algebraic summations of the experimental errors involved in the measurements and weighings. From these totals, it will be observed that the two greatest deviations from 100 in the weights of the products were *minus* 0·9 in Test F and *plus* 0·6 in Test C. It would thus appear that the weight balances can be relied upon to within *plus* or *minus* 1 p.ct.

Carbon Balances.

Carbon balances for the amounts of this element in the coal used in the tests and in the products of distillation are set out in Table XIV., in which the figures given represent the amounts of carbon calculated as percentages of the weight of coal charged into the retort. In Table XV. the figures have been brought up in such proportions that the amount of carbon in the coal is represented as 100. The items in Table XV., therefore, show the distribution of carbon in the products of distillation as percentages of the amounts present in the original coal. The weight of carbon in the liquor was assumed to be approximately the same as that found in the liquor obtained during the carbonization tests described in the Fourth Report.

Thermal Balances.

From the calorific values of the coal used in the tests and of the products of distillation, the thermal balances in Table XVI. have been constructed. The figures show the distribution of heat energy in therms resulting from the distillation of one ton of coal as charged. In Table XVII., the thermal values of one ton of coal are taken as 100, and the other figures are in proportion, so that the heat values of the products appear as percentages of the heat values of the coal. Deducting the sum of the heat contents of the products from 100, the figure obtained in each test represents the algebraic sum of the experimental errors and the heat changes (absorbed and evolved) in the process of carbonization.

Structure of Coke.

It would appear that, for a long time, there is likely to be a big demand for solid fuel to meet the requirements of the open grate in most households, so that if the emission of smoke from the domestic chimney is to be abolished, a satisfactory solid smokeless fuel should be found to replace coal. The logical method of preparing a solid smokeless fuel is to distil away the smoke-producing constituents of coal by a process of carbonization such as that practised in the gas industry, in which the valuable gaseous and liquid products are recovered.

The coke, destined largely to replace coal for domestic purposes, in addition to being smokeless, should possess the following properties:

(*a*) It should be easy to ignite.
(*b*) It should be free-burning, so that it may be kept alight without the necessity for maintaining a large body of fuel.
(*c*) It should be reasonably low in ash and moisture.
(*d*) It should be sufficiently robust to withstand handling and transport without serious breakage.
(*e*) It should be marketable at a price about the same as that demanded for household coal.

In the past, it was considered that coke must contain a considerable percentage of volatile matter, to satisfy the first two conditions (*a*) and (*b*). The work of numerous investigators, however, has led definitely to the conclusion that the content of volatile matter is not the only factor which exerts an influence on the relative ignitability, combustibility, and reactivity of coke. In fact, it appears possible to produce a coke with a low percentage of volatile matter, yet more reactive than another type of coke with a higher percentage of volatile matter, owing to differences in physical structure. The factors which influence coke structure include the character of the coal carbonized (in which the ash may play a part), the state of division of the coal, the method, speed, and duration of heating, and the temperature of carbonization. The work of various investigators has shown that the character of the coal to be carbonized may be controlled by first grinding and then mixing coals of different coking properties with one another or with coke breeze in different proportions. Though many different investigations on the preparation and structure of coke have been carried out, the fringe of the subject has only just been touched. It was, therefore, decided that an examination of the structure of the coke produced in the experiments described in this report, should be given special attention.

Preparation of Coke Sections.

Dr. Rose (Industrial and Engineering Chemistry 1925, **17**, 895) has developed a method for revealing the details of coke structure. The method, to which brief reference was made in the Fourteenth Report presented last year, consists of filling-in the open cells and cracks of a plane section with a suitable cement and polishing the surface so obtained. The cement used is mainly plaster of paris with

a small proportion of admixed magnesia. This gives an absolute contrast of the black carbonaceous material of the coke substance against a white background; and owing to the varying degrees of polish taken by the different parts of the coke, these appear in detail, the surface lending itself to macro- and micro-examination. The cementing material strengthens the delicate walls of the coke, and so prevents breakage during the process of polishing.

The method devised by Dr. Rose has been adopted for the examination of samples of the coke produced in the investigation described in this report and for other samples of particular interest. Photographs of two examples of coke sections prepared in plaster were given in the Fourteenth Report; and in view of inquiries which have since been received, it is believed that a description of the details of the method of preparation would prove of service. The following apparatus and materials are required.

(1) An abrasive elastic corundum wheel, $\frac{1}{16}$ in. to $\frac{1}{8}$ in. in thickness and 12 in. in diameter. The wheel, which is specified by the makers as grade 5, grain 36, is fitted to travel at a speed of 1750 r.p.m. If a corundum wheel is not available, a hack-saw may be used, but the work of cutting then becomes slow.

(2) A high-grade plaster of paris, passing through a 200-mesh sieve. Dental plaster has been found satisfactory.

(3) Light magnesia, to retard the setting of the plaster.

(4) Carborundum grinding powders of grades No. 280, 10 minute, 30 minute, and 60 minute. One pound of the No. 280 powder and $\frac{1}{4}$ lb. of each of the other grades is sufficient for a large number of sections.

(5) Levigated alumina, for final polishing.

(6) Suitable moulds of wood or iron. These moulds should have removable sides, to facilitate the removal of the plaster cast after solidification.

(7) Several sheets of fine grain ground glass, 12 in. square and $\frac{3}{8}$ in. in thickness.

A thin slice, $\frac{3}{8}$ in. to $\frac{3}{4}$ in. in thickness, is cut from the selected piece of coke, by the aid of the corundum wheel. The coke should be air dried before cutting, otherwise wet particles form a paste which enters the pores of the coke and causes trouble in subsequent operations. The surface selected for examination is then washed by means of a strong jet of water to remove any adhering dust from the coke pores. After draining, the section is ready for mounting in the white cement.

The inner surfaces of the mould of suitable size are smeared with vaseline, and the mould is placed on a sheet of glass, also smeared with vaseline. A mixture of plaster of paris with about 2 p.ct. by weight of light magnesia is then mixed with water in a suitable vessel. The water should be added gradually until the mixture is a moderately thick cream, and any lumps which form or any entrapped air bubbles must be removed by vigorous kneading. The correct consistency of the plaster cream can only be found by experience, but it is advisable that the cream should not be too thick, otherwise difficulty will be found in pushing the section of coke into the correct position. The mould is filled with the cream and the section of coke is pushed in until the surface for examination is on a level with the upper surface of the cement. The plaster is left to set for about half-an-hour, after which the supporting sides are removed. The plaster cast with its enclosed section is allowed to harden in a warm room for about an hour.

The specimen is now ready for filling and polishing. The exposed surface of the coke is wetted with water, a paste of the plaster and magnesia mixture is rubbed into the pores, and the surface is again washed with water. This procedure is repeated until the paste no longer becomes grey and gritty, when the surface of the cast is allowed to set by standing for some time. The grinding-down of the coke face is next commenced, and is continued, until the surface is flat, by rubbing on a sheet of ground glass, using the No. 280 carborundum powder as the grinding medium. During the grinding, the glass sheet is kept well wetted with water, and whenever the filling material becomes grey, or fresh pores are exposed, a further quantity of plaster-magnesia paste is rubbed-in and allowed to set. As the grinding proceeds, the surface of the coke should be examined periodically by means of a large hand lens, to enable the observation of empty pores or newly-exposed detail. The polishing is continued as described, the section being ground by successive carborundum powders, proceeding from the coarse to the fine in order of grade, all traces of each grade being removed by washing before commencing with the next. A separate sheet of ground glass should be reserved for each grade of polishing powder.

For most purposes, the 60-minute carborundum powder gives a satisfactory surface; but if it be desired to prepare photo-micrographs, a higher degree of polish is required. This high degree of polish can be obtained by using a thin paste of levigated alumina on ground glass as the polishing medium, and applying the correct rubbing pressure. Finally, the polished section is dried in a warm room, after which it is ready for examination.

Examination of Sections.

Sections of charcoals made from different varieties of wood and of cokes manufactured by different processes were prepared with the object of ascertaining the possibilities of the method of examination of the structure of the solid products of carbonization. The sections were examined under low and high power lenses, and the main points observed were noted. Full-size photographs were taken, and portions were photographed at magnifications of from five to sixty diameters. From examination under a high-power microscope, it was found that, owing to the different degrees of hardness of the material under observation and of the plaster, a certain amount of relief polishing had taken place, with the result that when attempts were made to prepare photo-micrographic records, some difficulty was experienced in securing the necessary depth of focus. Satisfactory photographs at magnifications of from 5 to 10 diameters, however, were taken with a camera lens of a focal length of 4 in.; and for magnifications of from 10 to 30 diameters, a cinema lens of a focal length of $1\frac{1}{2}$ in. was used. It was concluded that visual examination under high-power lenses is preferable to photographs at magnifications of more than about 30 diameters, owing to the variations in details of structure which usually occur in different parts of the same piece of coke; but at lower magnifications, photographs constitute permanent records and enable comparisons of different sections to be made easily.

The samples of wood charcoal examined were prepared from ash, silver birch, and oak. Each piece was cut in a direction corresponding with the cross-section of the tree, and the sections were set in plaster and polished. From the photographs of the polished surfaces, taken at five diameters and reproduced in figs. 13, 14, and 15, it will be observed that the structures of the different charcoals possess the main characteristics of the types of wood from which they were prepared. The white patches represent either cracks or pores which have been filled-in with plaster. The cells formed in the spring are generally large, but as the year advances the new cells produced are smaller and the walls are thicker. The changes from large to small cells, shown in figs. 13 and 15 for ash and oak, mark the rings of annual growth. The medullary rays are represented by dark lines radiating from the centre of the stem in directions at right angles to the annual rings. It will also be observed that the contraction cracks follow directions parallel with the medullary rays. In fig. 14, silver birch charcoal, the changes in cell size are not so marked, so that the annual rings are not so clearly defined as with ash and oak charcoals. Evidently the growth of silver birch is more regular, and the wood is of a finer grain than either ash or oak.

Photographs, taken at one and five diameters, of sections of beehive and bye-product oven coke are shown in figs. 16 to 20. The general appearance of the sample of beehive coke may be seen from fig. 16; and from fig. 17 the small cells in the walls of the larger cells can be observed. The dense appearance, representing deposited carbon, at the edge of the piece of beehive coke should also be noted. Figs. 18 and 19 represent bye-product oven coke; the two sections being taken from opposite ends of the same piece. The coke adjacent to the oven wall appears at the top of fig. 18 and the centre of the charge is shown in fig. 19. The dense black patches mark the positions of shale or

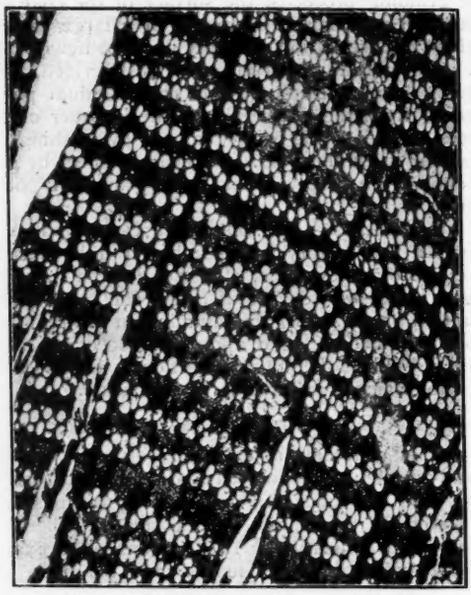


Fig. 13.—Ash Charcoal × 5 Diams.

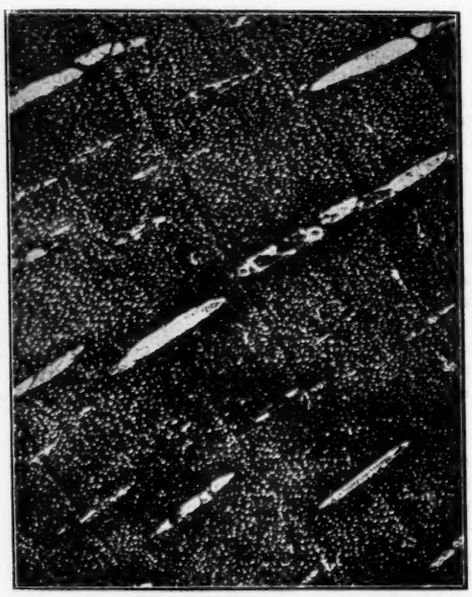


Fig. 14.—Silver Birch Charcoal × 5 Diams.

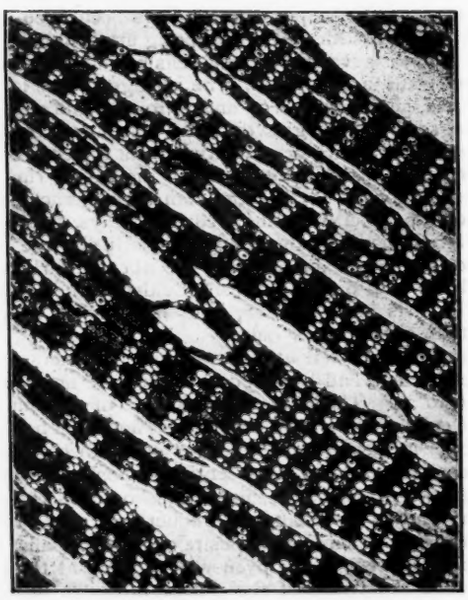


Fig. 15.—Oak Charcoal × 5 Diams.

Fig. 16.—Beehive Coke, Full Size.

Fig. 17.—Beehive Coke × 5 Diams.

Fig. 18.—Bye-Product Coke, Full Size.

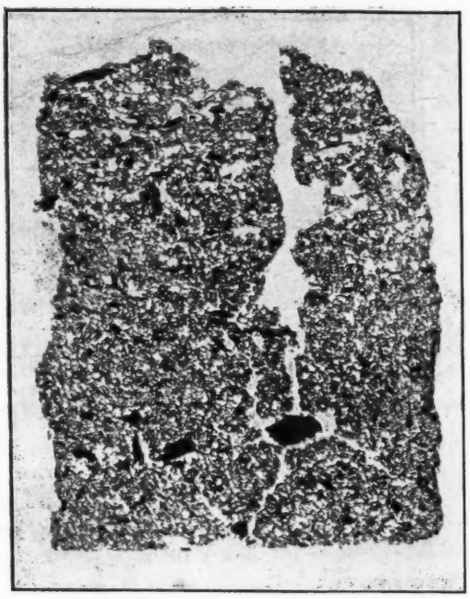


Fig. 19.—Bye-Product Coke, Full Size.

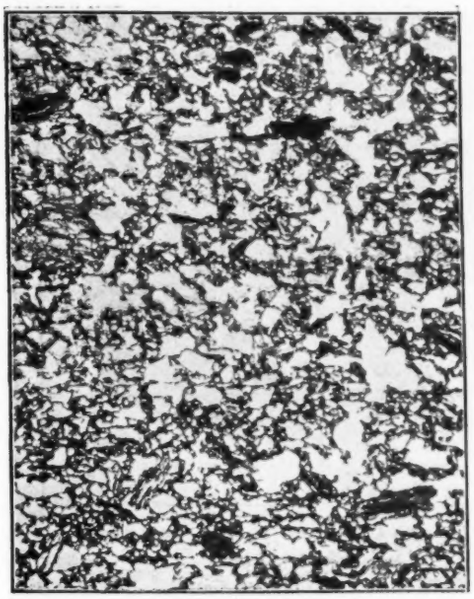


Fig. 20.—Bye-Product Coke × 5 Diams.

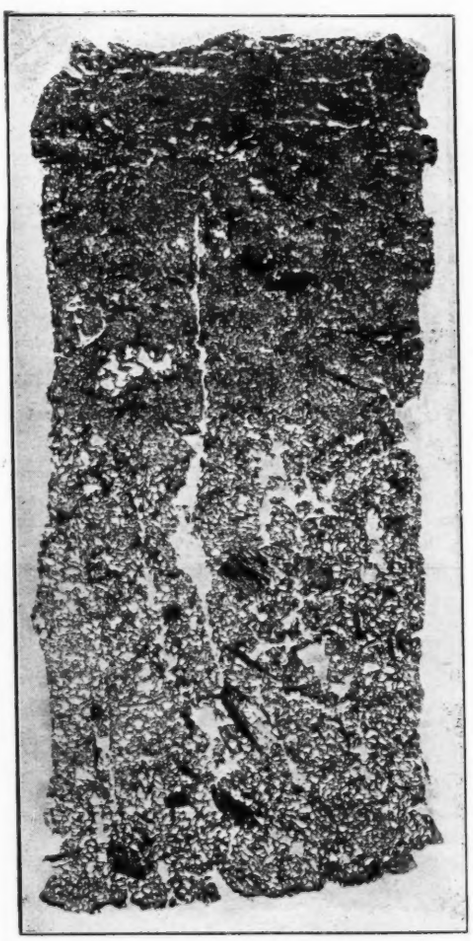


Fig. 21.—Low-Temperature Coke, Full Size.

Fig. 22.—Low-Temperature Coke × 5 Diams.

Fig. 23.—Low-Temperature Coke × 5 Diams.

Fig. 24.—Coke from $1\frac{1}{4}$–$\frac{3}{4}$ in. Coal Test A
× 0·5 Diam.

Fig. 25.—Coke from $\frac{3}{4}$–$\frac{1}{2}$ in. Coal Test B
× 0·5 Diam.

Fig. 26.—Coke from $\frac{1}{2}$–$\frac{1}{4}$ in. Coal Test C
× 0·5 Diam.

Fig. 27.—Coke from $\frac{1}{4}$–10 Mesh Coal Test D
× 0·5 Diam.

Fig. 28.—Coke from 10-30 Mesh Coal Test E
× 0·5 Diam.

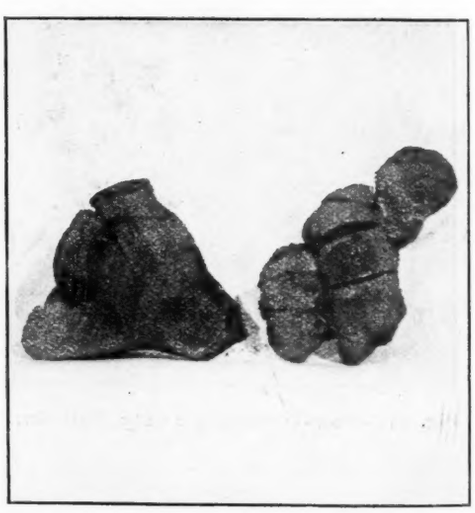


Fig. 29.—Coke from 30 Mesh Coal
× 0·5 Diam.

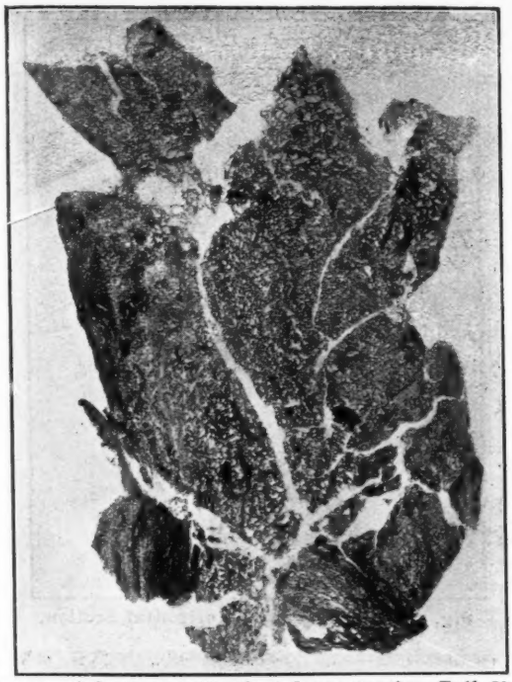


Fig. 30.—Coke Test A, Vertical Cross Section, Full Size.

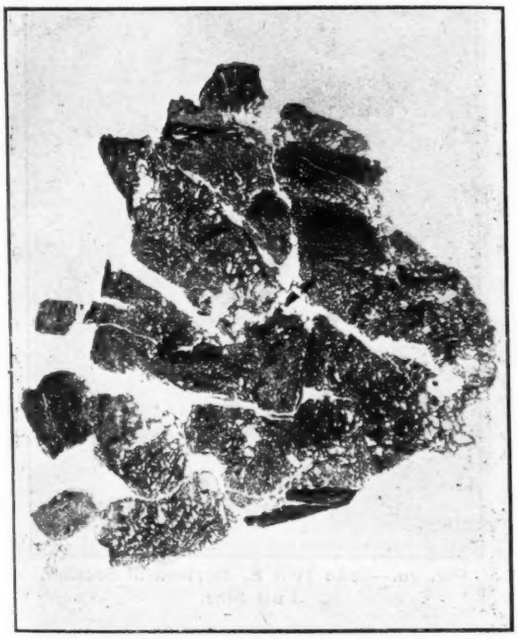


Fig. 31.—Coke Test B, Vertical Cross Section, Full Size.

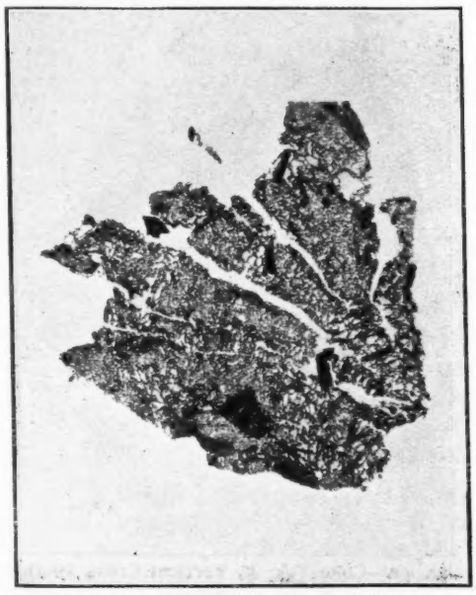


Fig. 32.—Coke Test C, Vertical Cross Section, Full Size.

Fig. 33.—Coke Test D, Vertical Cross Section, Full Size.

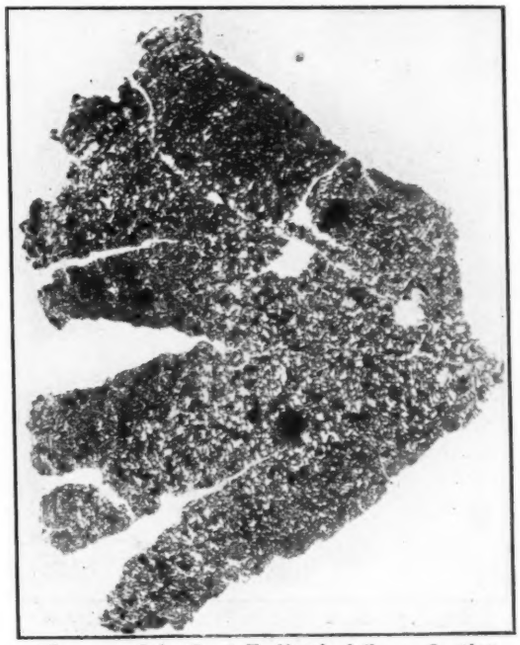


Fig. 34.—Coke Test E, Vertical Cross Section, Full Size.

Fig. 35.—Coke from Coal through 30 Mesh, Full Size.

Fig. 36.—Coke Test A, Horizontal Section, Full Size.

Fig. 37.—Coke Test B, Horizontal Section, Full Size.

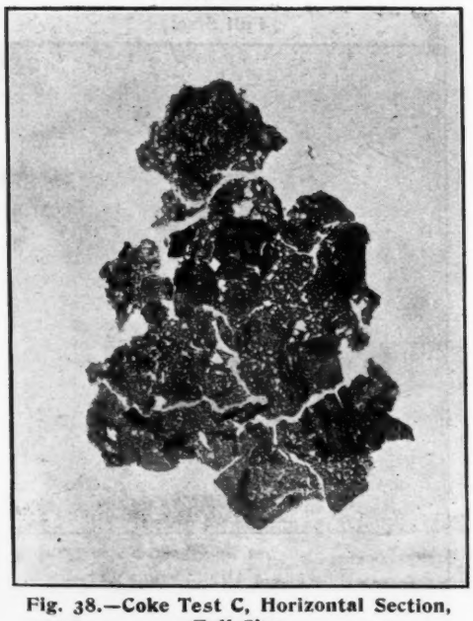


Fig. 38.—Coke Test C, Horizontal Section, Full Size.

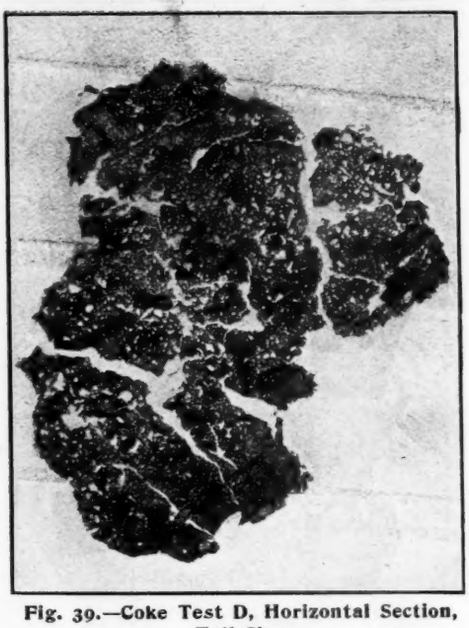


Fig. 39.—Coke Test D, Horizontal Section, Full Size.

Fig. 40.—Coke Test E, Horizontal Section, Full Size.

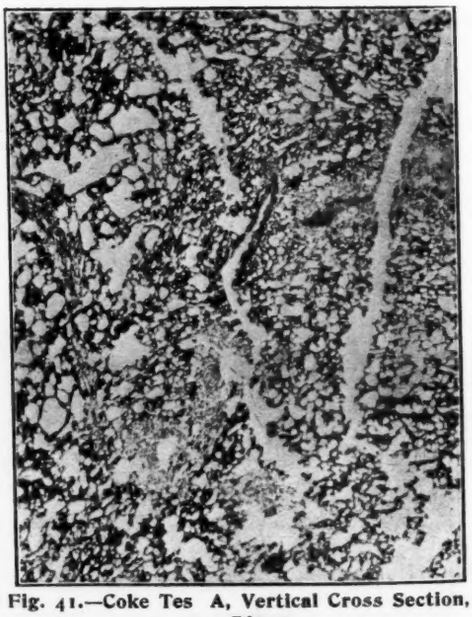


Fig. 41.—Coke Tes A, Vertical Cross Section, × 5 Diams.

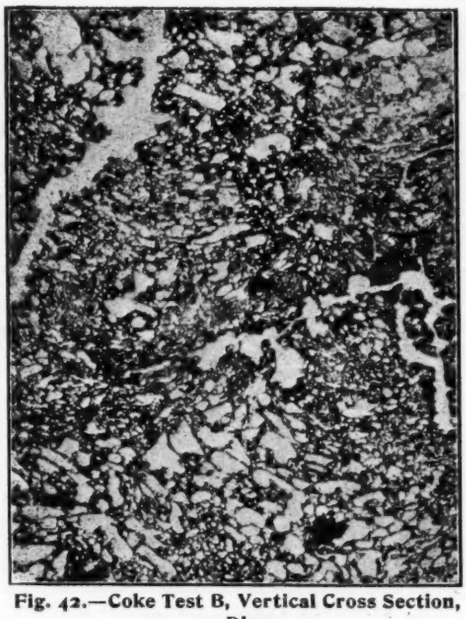


Fig. 42.—Coke Test B, Vertical Cross Section, × 5 Diams.

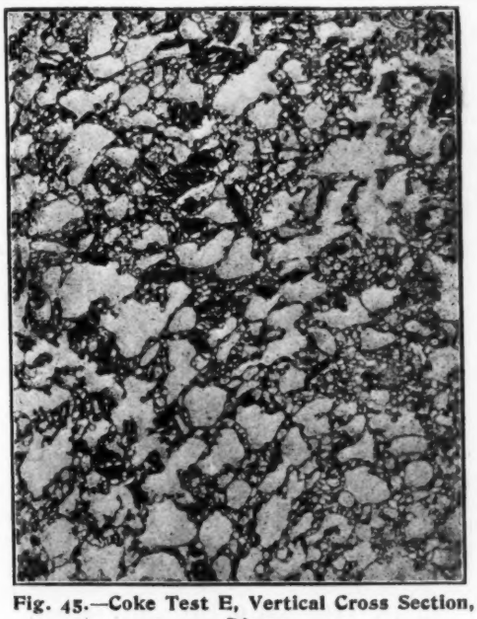


Fig. 45.—Coke Test E, Vertical Cross Section, × 5 Diams.

Fig. 43.—Coke Test C, Vertical Cross Section, × 5 Diams.

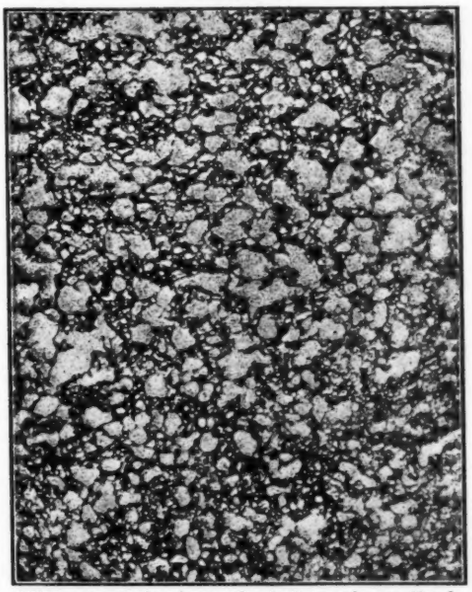


Fig. 46.—Coke from Coal through 30 Mesh × 5 Diams.

Fig. 44.—Coke Test D, Vertical Cross Section, × 5 Diams.

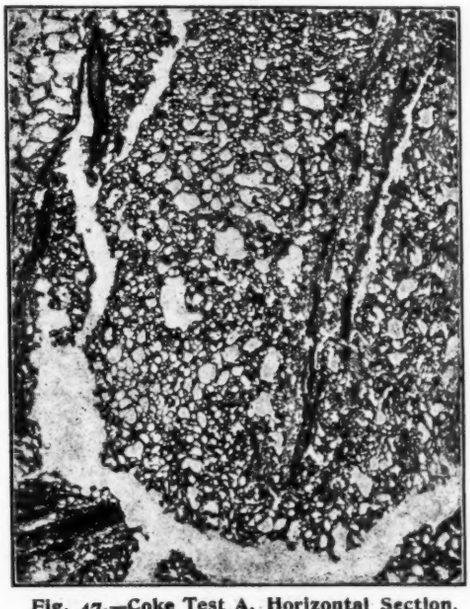


Fig. 47.—Coke Test A, Horizontal Section, × 5 Diams.

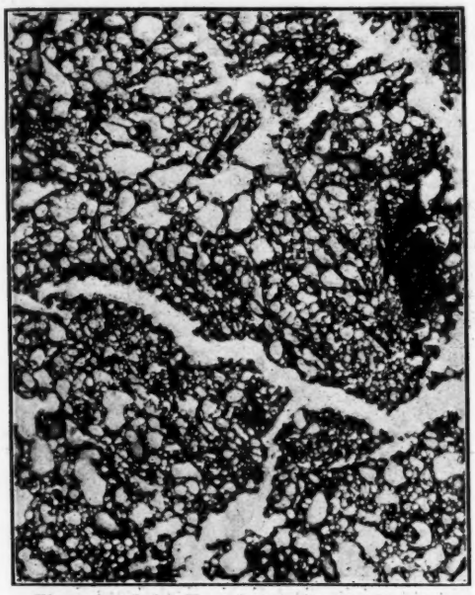


Fig. 48.—Coke Test B, Horizontal Section, × 5 Diams.

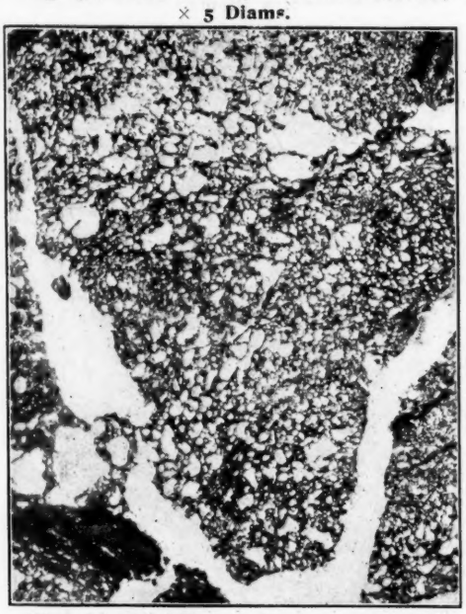


Fig. 49.—Coke Test C, Horizontal Section, × 5 Diams.

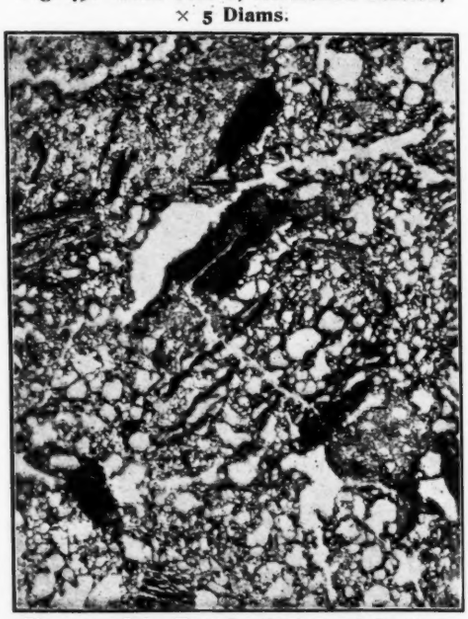


Fig. 50.—Coke Test D, Horizontal Section, × 5 Diams.

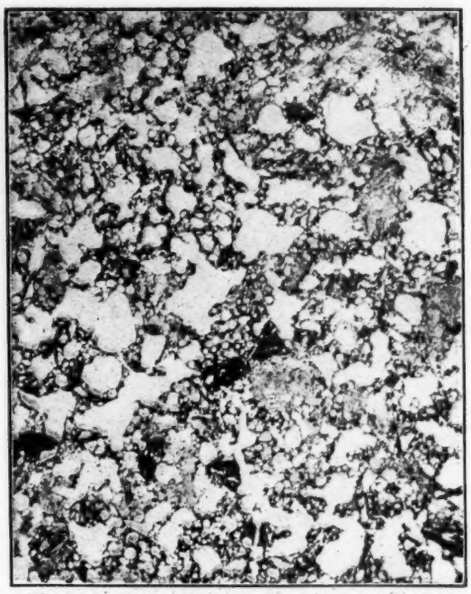


Fig. 51.—Coke Test E, Horizontal Section, × 5 Diams.

Fig. 52.—Coke from Sharlston Wallsend Coal × 5 Diams.

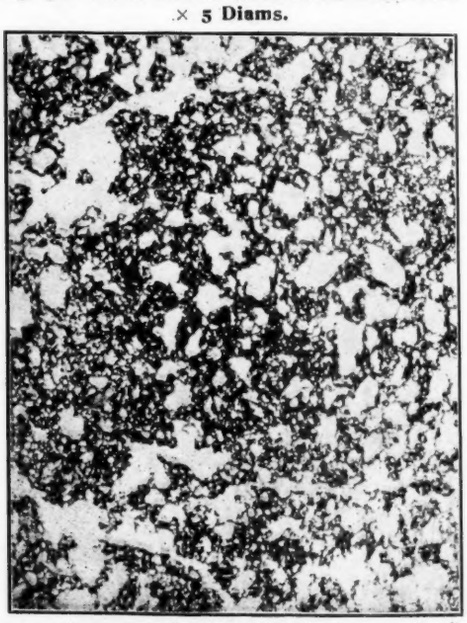


Fig. 53.—Coke from Sharlston Wallsend Coal and 5 p.ct. CaO × 5 Diams

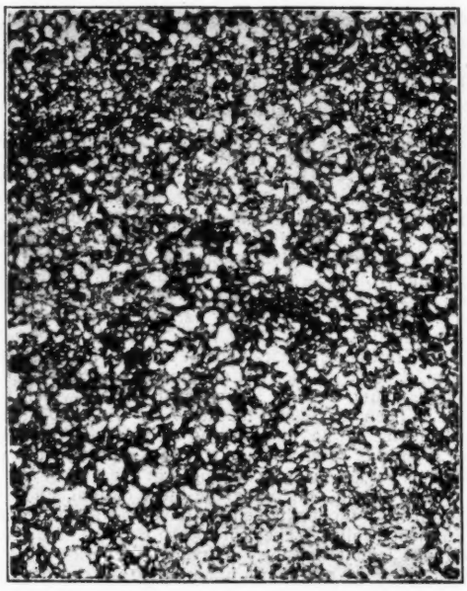


Fig. 54.—Coke from Sharlston Wallsend Coal and 5 p.ct. Fe_2O_3 × 5 Diams.

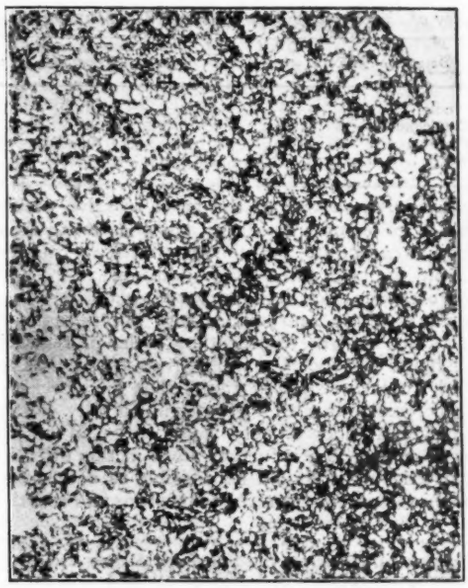


Fig. 55.—Coke from Sharlston Wallsend Coal and 5 p.ct. Na_2O × 5 Diams.

other foreign matter rich in ash. The photograph at five diameters, fig. 20, is taken from the same piece of bye-product coke about midway between the centre of the charge and the oven wall. Figs. 16 to 20 show considerable differences in the structure of the particular samples of beehive and bye-product coke.

Sections of a piece of coke prepared by a process of low-temperature carbonization, in which the retorts were heated externally, are given in figs. 21, 22, and 23. The lower edge of the coke, fig. 21, was adjacent to the retort wall, and the upper edge was in the centre of the retort. The change in structure from the wall to the centre of the charge is clearly shown. It would appear that a considerable drop in the temperature of carbonization occurred from the retort wall to the centre. The differences in structure are more definitely seen on comparing fig. 22 taken from an area of the section near the retort wall, with fig. 23 taken from the centre of the charge. Apparently, some of the coal in the centre has undergone very little carbonization, the small cells in the walls of the larger cells not being fully developed.

The sections of charcoal and of different types of coke shown in figs. 13 to 23, illustrate the possibilities in this method of examination of coke structure.

Influence of Sizes of Coal Particles on the Coke Produced.

The cokes produced by the carbonization of different grades of the Nottinghamshire coal used in the experiments described in this report differed considerably in appearance according to the sizes of the particles of coal charged into the retort; but a reduction in the period of carbonization from 2¾ hours to 2 hours had no effect which could be observed by visual examination.

Photographs of typical lumps of coke produced from the different grades of sizes of coal under the particular conditions of carbonization already described, are shown in figs. 24 to 29. The cauliflower ends adjacent to the walls of the retort, and the cracks or crevices running radially from the wall to the centre of the charge, can be observed. The most noticeable point is that as the particles of coal were diminished in size, the resultant coke became more uniform in structure, and less liable to break up into small pieces. The coke shown in fig. 29 was obtained in the trials made to carbonize coal crushed to pass through 30 mesh sieves. When this grade was charged into the retort, the gas evolved immediately after the door had been closed pushed a portion of the charge forward, and blocked the gas offtake. The retort door was then opened, and the charge was allowed to burn off. The pieces of coke shown in fig. 29 were taken from the centre of the charge, which would not have been affected by the circulation of air into the open retort.

Full-size photographs of two sets of plaster sections of the cokes prepared from the different grades of coal are given in figs. 30 to 40. The structure of the cokes in sections cut vertically across the retort are shown in figs. 30 to 35. The portions of coke against the wall of the retort and those near the centre of the charge can be recognized from the fact that the cracks run radially from the outside to the centre. The sections in figs. 36 to 40 were cut in directions corresponding with horizontal longitudinal sections of the retort at positions about midway between the centre and outside of the charge. The large pieces of material rich in ash appear as dense black patches in the cokes prepared from the grades of sizes greater than ¼ in. In the coke made from the smaller grades of coal, the constituents rich in ash were more evenly distributed; and the general structure of the coke became more uniform as the sizes of the coal particles were diminished. The greater uniformity of coke structure with the smaller sizes of particles of coal is more clearly brought out in figs. 41 to 51, which are reproductions, at a magnification of five diameters, of photographs of areas of the sections shown in figs. 30 to 40. It will also be noticed that in figs. 45, 46, and 51, as compared with figs. 40 to 44, and 47 to 50, the walls of the larger cells are thinner and contain large numbers of very small pores.

Relationship Between Coke Structure and Reactivity.

Until work on this subject has been greatly extended, very definite conclusions cannot be drawn as to the exact relationship which exists between the structure of coke and reactivity towards reagents such as steam, air, and carbon dioxide. The research staff, however, were indebted to Prof. J. W. Cobb and Mr. C. B. Marson* for four samples of coke prepared from Sharlston Wallsend coal ground to pass 20 mesh sieves and carbonized at 800° C. in a laboratory apparatus. This coal, which was carefully selected, contained only about 0·9 p.ct. of ash. The samples of coke supplied were obtained by the carbonization of (1) the "pure" coal, (2) a mixture of 95 parts by weight of coal and 5 parts of lime (CaO), (3) 95 parts of coal and 5 parts of iron oxide (Fe_2O_3), and (4) 95 parts of coal and 5 parts of sodium oxide (Na_2O) added in the form of sodium carbonate (Na_2CO_3). The cokes prepared in this manner were then submitted at 1000° C. to the action of steam passed at definite rates. The investigators have kindly supplied the following figures to show the percentages of steam decomposed when the rate of flow was 10 litres per hour.

* Gas Research Fellowship Report, 1926.

Reactivity of Cokes with Steam at 1000° C. (Marson and Cobb).

Description of Coke.	Steam Decomposed, P.Ct.
"Pure" coke	61
5 p.ct. CaO coke	82
5 p.ct. Fe_2O_3 ,,	91
5 p.ct. Na_2O ,,	98

These figures show that the most reactive of the four samples of coke towards steam was that made from coal and sodium carbonate, and the least reactive was the coke made from the coal without any addition.

The research staff has prepared plaster sections of specimens of these four cokes, and photographs at five diameters are shown, in ascending order of reactivity towards steam at 1000° C., in figs. 52 to 55. It will be observed from these photographs that an increase in reactivity corresponds with a greater uniformity of structure and a larger number of very small pores in the walls of the larger cells. When further work in this direction has been carried out, it should be possible to determine what relationships exist between coke structure and reactivity.

Prof. COBB, introducing the Sixteenth Report, said:

In introducing this report I may be allowed to point out that it constitutes a new departure of some moment in the work of the Committee. We were occupied for a number of years in obtaining data concerning the efficiency of various gas-works processes, such as carbonization in vertical retorts with and without steaming, gasification in water gas plants with and without carburetting, and the economies obtainable from waste-heat boilers. Chemical and thermal balances of these processes were struck with the greatest accuracy which we could possibly obtain, and the information so supplied to the gas industry has already been, we believe, and is likely to be, of service.

We may have to investigate other and new processes in the same way, but the work on which we are engaged at the present time is demanded by the necessity of placing the whole process of carbonization under very careful review and systematic examination, so as to get the best possible results out of the process. The gas industry not only provides the purest and most controllable form of smokeless fuel in the gas—the only form of fuel from which the extraction of sulphur compounds is carried out—but a solid smokeless fuel in the coke, and a liquid fuel in the tar. These truths are receiving a degree of recognition in the country never before accorded to them; and the utmost care and thoroughness in investigating all that the carbonization process can do with coal is not only justifiable, but an imperative necessity. The Committee has adopted the policy of making this thorough investigation, and has planned to investigate the importance of a number of factors in the carbonization process in a more thorough and quantitative way than has been done before. The first instalment of this work is forthcoming in the Sixteenth Report, of which Dr. Parker will give an account. The factor first investigated has been that of the size of the coal.

In order to carry out the investigation properly, it will be necessary to make a large number of experiments on the small working scale, and then probably to select from these some few experiments which ought to be repeated on the full working scale. The work has been started in the horizontal retort section of the Corbet-Woodall experimental plant, the design of which has been modified with great skill by Dr. Parker and his Assistants, in order to meet the conditions of the experiments in important respects. For this and the rest of their work the Committee would like to express its thanks.

In addition to measurements of gas and tar, the precision of working has enabled figures to be obtained for the thermal balance of carbonization which confirm, with a degree of certainty not before obtainable, the important fact that the products contain within 2 or 3 p.ct. as much potential heat of combustion as the coal itself—that is, that the loss in carbonization is extremely small.

They have also prepared samples of cokes by the plaster of paris method, due to Dr. Rose, which exhibits differences of structure in a very striking way. I should also like to thank them for having prepared and examined samples of the special cokes made by Dr. Marson in our study of the influence of ash constituents during carbonization and gasification—a subject which seems to be of primary importance, and will be dealt with in the Report of the Gas Research Fellow.

I should like to remedy one omission in the report itself, an omission which I noticed only the last time I read it through, but which should be remedied. There is no mention there—as I am certain the Committee would like me to mention—of the fact that we had the advantage, before starting on this work, of a preliminary consultation with Dr. Carpenter and Mr. E. V. Evans, of the South Metropolitan Gas Company, who have concerned themselves so much with carbonization problems. Of this we should like to make due recognition, and to tender our thanks.

Dr. A. PARKER then gave an admirable summary of the Sixteenth Report.

Discussion.

The PRESIDENT: The Fifteenth and Sixteenth Reports are now open for discussion. Both contain information of vital importance. Necessarily some of the work must be of an interim nature, and the work which Mr. Wood has been engaged upon is perhaps of more importance than appears on the surface. It is absolutely necessary that we should know if there are products of carbon monoxide arising from the use of gas appliances, and, as in other directions, it is very necessary that we should not be pilloried on false information. When you know that you can detect carbon monoxide in minute quantities, such as those likely to be found in the products of combustion, in the air of cities, or in the air of rooms, you will, I am sure, agree with me that no time has been wasted. It is our bounden duty to have a means of testing which is above suspicion. Then in regard to the work which Dr. Parker is engaged upon, as he has indicated, we have started upon another avenue of research, and this is a report by the way. I commend to your notice the balances at the end of the report, which I am certain will repay the most careful study. As in the case of other reports which we have had from Leeds, these are of immense value. They, of course, require study, and perhaps do not lend themselves to ready discussion; yet—and I hope it is so—there are points upon which we can usefully confer together. Therefore, having given them attention—because you cannot discuss these things unless you have—I hope you will favour us with your observations or questions, so that our eminent Research Chemists can answer.

Mr. J. P. LEATHER: I should like to ask a question. I have not studied the reports sufficiently to be able to comment upon many of the important things contained in them, which I am sure will be of great value; but in looking through them I was rather struck by the way in which the sampling of the gas was carried out, and would like to ask whether there has been any trouble through the use of geared meters. In my experience with geared meters I have had difficulty. Comparing the figures, it appears that the one meter, with the 1 c.ft. capacity per revolution, must have been revolving at the rate of 240 revolutions per hour, which is rather a high velocity for a wet meter. The other meter runs at one-third that number of revolutions, and, therefore, would not be quite so over-worked. The effect would be that the meter which was over-worked would probably be registering somewhat slow. In cases where I have used geared meters they have sometimes gone so fast as to unseal the diaphragms; but no doubt this has been avoided by the way in which the pressures at the outlet of the meters were adjusted in this case. Still, it occurs to me that there might be a slight tendency in that direction; and I should like to know whether anything of the kind has been found by Dr. Parker.

Dr. G. WEYMAN (Newcastle-upon-Tyne): I should like to congratulate the Gas Investigation Committee for having chosen a wise procedure in starting this investigation in the new plant at Leeds by the examination of the physical conditions of the charge of coal, and the way in which those physical conditions influence carbonization. I should also like to congratulate Dr. Parker and the Research Chemists upon the way in which they have made a start. I am peculiarly interested in this work; and one point which I think is worth keeping in mind is that the test plant at Leeds, taking 30 lbs. of coal, is about twelve times the capacity of the coal testing plant which we have had in Newcastle for some considerable time. The Sixteenth Report tells us that this particular scale of plant was chosen in preference to one with a capacity of 1000th part of a ton, owing to the smaller plant not giving sufficient tar yields for examination, and also because coal of the larger sizes could not be examined very well in so small a retort. I think, however, that the smaller retort is capable of being used for sizes as great as are dealt with in this report, and, moreover, you can always get sufficient tar for your examination by multiplying the number of charges from the same coal. This in itself provides a really good check on the working. In comparing the results obtained at Leeds, there is general agreement; in particular the curves of figs. 9, 11, and 12 might almost have been reproduced from those given in my 1922 paper. But there are two points which stand out in contrast, and are probably cause and effect. The first is the evidently large amount of cracking of the tar which has been going on in spite of the descension pipe, which one would imagine would have reduced the amount below normal, and again the high quality of the coal gas, which averages up to 600 B.Th.U. At Newcastle the calorific value on the test plant rarely exceeds 570, with, of course, Durham coal. The tar yield is from 10 to 12 gallons, and the pitch rarely has to be removed from the side. The offtake pipe is at the side, and not at the bottom, but the pitch has rarely to be removed from that side. The formation of pitch at Leeds at the rate of 37 lbs. per ton seems to be extraordinary. I think this point needs careful examination, and the conditions need adjustment, because it is obvious that those conditions of cracking are not such as apply at the present time, at any rate in the ordinary

scale plant. If it is considered advisable to crack the tar, one would imagine that it would have to be carried out under conditions which could be controlled. There are many points in this investigation which are of exceedingly great interest. For example, the clockwork mechanism which records the rate of gas evolution is a great improvement on that which we have had in use. I am not sure whether an application of this to the ordinary station meters in many cases might not be very useful. I have great pleasure in congratulating the authors of the papers.

Dr. C. H. LANDER (Director of the Fuel Research Station, Greenwich): I did not come to the meeting with the intention of speaking, but there are perhaps one or two points of interest, and some striking agreements which I have noticed in the work of Dr. Parker and certain investigations that we have been doing during the last twelve months at East Greenwich. The two investigations are on totally different lines—as you know, some of our work involves the vexed problem of low-temperature carbonization—and we have been running sometime now (nearly twelve months) with a large setting of cast-iron retorts some 20 ft. high, about 4 ft. 6 in. in one dimension by, I think, from 9 in. at the top to 11 in. at the bottom. Those retorts have been worked at a temperature of 625° C. Dr. Parker's setting, of course, can work at much higher temperatures, and is much smaller. Neither set of experiments, needless to say, is absolutely and directly applicable to full-scale working. A point of agreement I want to mention is in connection with the size of the coal. When working these settings with, for instance, Mitchell Main nuts—of which we have talked at great length on previous occasions, both here and elsewhere—a strongly caking coal, or another nut coal, Garforth nuts, a medium caking coal, and such coals as that in the nut size, we get exactly the same effect, inasmuch as we get a large throughput. Our retorts give about 4 tons a day when we use those large sizes. The tar or oil yield, of course—this being a low-temperature product—is also high. With the weakly coking coals, we have had over 18 and sometimes 19 gallons. With the Mitchell Main coal the tar yield has not been quite so great; but when we have started to work on the finer coals, or when we have broken our coal up, the throughput has gone down suddenly to about 2 tons, or half, so that the effect is exactly the same, but owing to the different conditions of temperature, and so on, it is perhaps more marked, as one would expect. Then again, when using the fine coals or breaking the coal down—passing it through a double squirrel-cage disintegrator—we get the same effect reflected in the oil yield, inasmuch as from the small coal we get both low oil yield and low throughput. The explanation, of course, has already been given, though up to the present we have not got any definite relation between the calorific value of the gas and the amount of tar produced, or even the amount of the gas. One would expect the cracking to increase the amount of gas, but in our case it has not always done this. However, I am merely giving you a few discursive remarks about an investigation which contains points of similarity to that dealt with in the report, but which has been conducted for a different purpose. I have not the slightest doubt, if we were to continue it on the lines of investigating more closely the effect of size, the points I have referred to would be confirmed.

Dr. PARKER, replying to the discussion, said: Not many points of criticism have been raised. Mr. Leather referred to the arrangement for sampling. Well, the larger meter used in the sampling apparatus is of such capacity that it passes 1 c.ft. per revolution, and admittedly in the early stages of carbonization it would appear to be travelling rather faster than was intended by the makers. But the fact remains that the difference in pressure between the inlet and outlet of the meter was not more than about 4-tenths. The meter is running very smoothly, and there is practically no increase in friction as the result of the gearing mechanism. We have made it up ourselves from clock wheels, and "Meccano" sets have come in most useful. With regard to the small meter, of only $\frac{1}{10}$ c.ft. capacity per revolution, these calorimeter meters certainly do by-pass gas in some cases if you get a difference in pressure between the inlet and the outlet of only 3-tenths. But meters vary; you cannot guarantee exactly the same for each meter, though they are supposed to be the same. In this case, however, we have attached a slope gauge from the inlet to the outlet of the sampling meter, and to this outlet the gas sample holder is connected; and we adjust the weights on the holder so that the difference in pressure between the inlet and the outlet of the sampling meter is about 1-tenth in. water-gauge. This is easy, because the slope gauge exaggerates ten times, so that it means a movement on the gauge of 1 in. We have experienced no difficulty whatever. Of course, the meters are calibrated periodically, but this high rate occurs only in the first few minutes of carbonization. After that the rate of flow is well within the capacity of the big meter. We have, however, observed no big pressure difference, and the results are comparable. The question of pressure difference, inlet and outlet, of two meters geared together is certainly important, and must be watched, but we have had no trouble. Dr. Weyman referred to one or two points. Before we decided to instal a "cronite" retort, we discussed whether to instal a retort of "cronite" alloy, cast iron, silica, or of a certain other refractory material known as "morganite," I think; but in the end we decided upon "cronite," largely as the result of Dr. Weyman's experiences with an alloy made by the same Company, and out of which his 10ooth-ton experimental retort had been made. Though it is more expensive than cast iron in initial cost, there is no doubt that as far as we have gone already it has worked out cheaper, because it has lasted so much longer and is not showing signs of wear even now. With regard to the size of plant, Dr. Weyman is of opinion that he could get results on the $1\frac{1}{4}$-in. coal equally well on the small plant. Our retort has an internal diameter of only 8 in., and we found, from a dimensional analysis of sieved coal, that $1\frac{1}{4}$-in. to $\frac{3}{4}$-in. coal might contain pieces perhaps as long as 3 in., with the narrow side only $\frac{1}{4}$ in. The pieces are not cubes, but all sorts of shapes, and we decided that it might be possible to have only three or four pieces across the retort, or might get down to two if we had larger coal. We thus felt that we could rely on the results for the particular size of coal with this particular retort, but that we should not care to go much further. On the size of plant, I admit, of course, that one can get sufficient tar for sampling and analysis purposes by running a large number of carbonization experiments, but we endeavoured to cut down to the minimum the number of individual experiments required to get a satisfactory size of sample; and the reason for this is given in the report. Of course, we should not necessarily advocate exactly the same retort for general testing purposes, for testing consignments of coal. This retort was put up for special experimental work. We were not out necessarily to repeat ordinary conditions, but wanted to find out the effect of temperature changes, changes in size of coal, and so on, and to find where we can improve present working conditions. This really explains one or two points raised by Dr. Weyman. We intend later to cover other temperatures. We know that the temperature and conditions used will not give results exactly the same as on the large scale. We can easily get them by lowering the temperature, but we want the fundamentals, and not to repeat ordinary practice. Dr. Weyman also referred to the curves in figs. 9, 11, and 12, relating to rates of gas production. They certainly confirm to a very large degree a number of points raised in the paper presented by Dr. Weyman in 1922, and there are many points of agreement in those curves. The only point of difference I remember is that in our curve of gas production in fig. 9 we start right away from zero with the maximum rate of production, whereas usually previous investigators have shown a slow rate to start with, and at the end of about four minutes an increase in the rate of production. We seem to get the maximum within one minute of charging the coal into the retort. The gas comes off faster then than at any other time; and I think that is accounted for by the fact that we charge the coal direct into the retort, whereas in the usual small-scale apparatus the coal is put into a metal tray, which is inserted in the retort. There is a time lag while the heat is transmitted to the tray and then to the coal, and they get a slow rate at first, which increases and then falls off again. I was interested to hear from Dr. Lander that the results obtained at Greenwich largely confirm ours as regards the effect of size of coal. I have only glanced through Mr. Rhead's paper ("Investigation of Some of the Factors Affecting Carbonization in Continuous Vertical Retorts"), but I find that he, working again on entirely different lines from those of Dr. Lander or ourselves, has discovered points which more or less confirm ours. We are all working from different angles, but seem to be bringing out the same points.

The PRESIDENT: I now formally move the adoption of these reports, and I will ask Mr. Wilson to second the motion.

Mr. A. WILSON, O.B.E. (Past-President): I formally second the adoption of the reports, and should like to take the opportunity to make perfectly sure that size of the coal carbonized is alone responsible for the difference in the structure of these two samples of coke you have been good enough to bring here.

Dr. PARKER: That is so. The coal was of exactly the same quality, and was graded. Each sample, no matter what the size, contains approximately the same amount of ash. Size alone is responsible for the difference.

The reports were adopted.

THE DEVELOPMENT AND RECONSTRUCTION OF THE PORTSLADE (BRIGHTON) GAS-WORKS.

By C. H. RUTTER, M.Inst.C.E., of Brighton.

Brighton and the surrounding districts were originally supplied with gas by two Companies, the Brighton Gas Light and Coke Company, formed in 1818, with works at Black Rock, at the eastern end of Brighton, and the Brighton and Hove General Gas Company, formed in 1825, with works at the western end of Hove.

In 1870 the site of the Brighton and Hove General Gas Company's Works at Hove did not permit of any further extensions; land was therefore acquired at Portslade on the Shoreham Harbour, which gave facilities for bringing coal by sea, and works were erected there. In 1882 the two Companies were amalgamated, and the manufacture of gas at the Black Rock Works ceased in 1885, the whole of the manufacture being transferred to the Portslade Works.

The original works at Portslade, built in 1870-71, formed the subject of a paper read by the late Mr. J. B. Paddon, M.Inst.C.E., formerly the Chief Engineer of the Company, at a meeting of the Institution of Civil Engineers on Feb. 3, 1874. Since then there has been no authentic record of the developments which have taken place; and one object of this paper is to give an account of extensions effected since 1919.

The works were constructed on a piece of land measuring about 700 ft. by 450 ft., or 7 acres. By subsequent purchases of land on each side of the site, the area now occupied by the works of the Company extends approximately to 40 acres, lying on the south side of the eastern arm of Shoreham Harbour, between the waters of the harbour and the sea.

By permission of the Institution of Civil Engineers, some of the original drawings are now reproduced, with extracts from Mr. Paddon's paper; fig. 1 being from a plan showing the lay-out of the original works. From this it will be observed that in 1870 the works consisted of a retort house and coal stores, an engine and meter house, scrubber house, boiler house, and purifying shed, with a range of buildings for offices and stores, and a residuals shed.

Coal was conveyed to the Company's own wharf by ships of about 600 tons carrying capacity, and discharged by means of steam cranes lifting 25 tons per hour per crane, and transported into the retort house and coal store in hand-pushed trucks (each carrying 10 cwt.) over a series of light tram lines. With regard to the original carbonizing plant, the following is extracted from Mr. Paddon's paper: "There are 24 benches of retorts; each bench has 8 long retorts and each retort 2 mouthpieces, so that there are 384 mouthpieces in all. The retorts are cylinders 16 in. in diameter and 20 ft. long, and each will carbonize one ton of coal per day. Allowing one-sixth of the number for reserve, the remainder will produce 1½ million c.ft. of gas every 24 hours, or 300 million c.ft. per annum."

From these particulars, it will be observed that the make of gas per ton was calculated at 9500 c.ft.—a figure which at the present time would undoubtedly be considered low. The ancillary plant of the original works was fully described by Mr. Paddon, and particular reference was made to the design of the Paddon patent rotary scrubbers, the first of their kind ever made. The description in the paper reads: "They consist of a series of perforated discs or screens, which revolve slowly in a tank half-filled with liquor, so that the gas may pass through the portions of the screens above water. The gas is by this means divided into a series of small streams, each stream being brought equally into repeated contact with a thoroughly wetted surface. The screens being fitted at the edge with an elastic fringe made by preference of bass, there is but little friction against the circular portion of the tank; and as no advantage is gained by a speed of more than 50 revolutions per hour, the power required to keep the screens in motion is very small. . . . These scrubbers remove 95 p.ct. of the ammonia, 50 p.ct. of the sulphuretted hydrogen, and from 30 to 50 p.ct. of the carbonic acid existing in the crude gas." The original scrubbers, and others of similar design, are still in use at the works, and continue to give excellent service. The most recent tests give their efficiency as 93 p.ct. of ammonia, 30 p.ct. of sulphuretted hydrogen, and 30½ p.ct. of CO_2; but this was when passing 50 p.ct. more gas than the quantity for which they were designed.

The purifiers as shown in fig. 1 were erected on a series of wooden piles so as to raise them 3 ft. above the surface of the ground, as the site at that time was level with the high-water mark of the sea. The purifiers as constructed in 1870 were still in use as recently as the year 1925, when they were replaced by larger vessels. The piles and waling on which the purifiers were originally built 55 years ago, when taken out last year, were found to be in excellent condition, with no trace of decay in any of them. They were stored for use in groyning and other sea defence work, which is constantly being undertaken by the Company on the seaward side of the works.

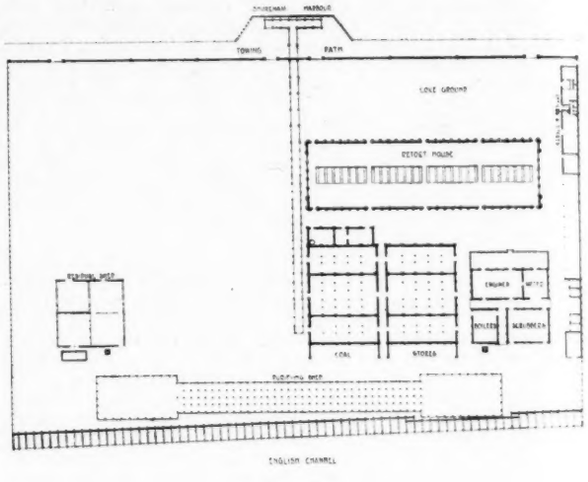


Fig. 1.

The next historical fact to be recorded in connection with the Portslade Works is the construction of No. 2 section, which took place in the years 1880-82. The productive capacity of No. 1 retort house was then becoming somewhat strained. It was decided to construct No. 2 section on very similar lines to the first section of the works, but with somewhat larger apparatus and connections. The retort house was a replica of No. 1 retort house, with exactly the same number of retorts, and therefore the same maximum capacity—namely, 2 million c.ft. per day. The same coal gantry constructed for No. 1 retort house served also No. 2 retort house and the coal stores, as shown on the plan, until 1887, when a second gantry was erected.

Upon the amalgamation of the two Companies in 1882 the manufacture of gas was gradually transferred from the Black Rock Works to the Portslade Works, and by the end of 1885, when the transference was complete, the make of gas at Portslade reached 756 millions, and five years later just over 900 millions. Further extensions were evidently necessary; and the third section of the works was designed.

No. 3 retort house was made 50 p.ct. larger than either No. 1 or No. 2 retort houses, with the intention of installing similar retorts to a maximum of 3 million c.ft. per day, or 600 millions per annum; but before the house could be completely equipped with the six blocks of retorts (instead of four blocks, as in the other houses), the process of gas production was radically altered by the introduction of the manufacture of carburetted water gas. In 1895 two Humphreys & Glasgow's water gas sets, each of them of a nominal capacity of 750,000 c.ft. per

day, were erected in the west end of No. 3 retort house; the Brighton Company being one of the first half-dozen companies in England to instal a plant of this description. This method of gas manufacture proved so economical with the then low price of gas oil that further extensions and enlargements of the carburetted water gas plant were effected in 1899 and 1901, and for the time stopped all expansions in the coal carbonizing plant.

When the first carburetted water gas plant was erected, the total annual make of gas was just over 1000 million

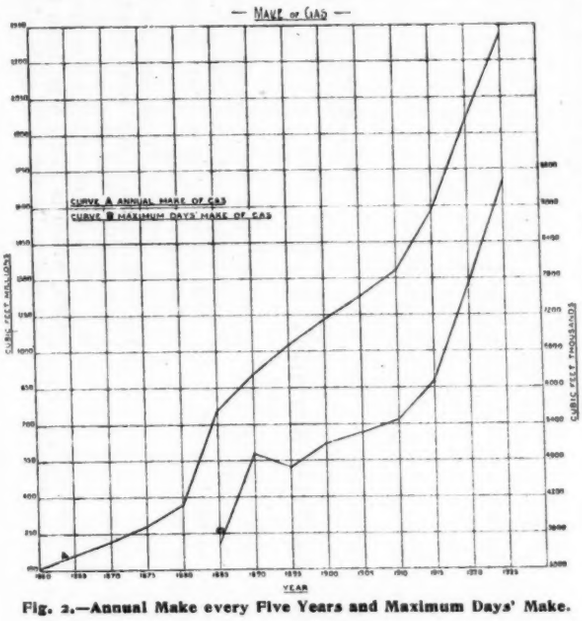


Fig. 2.—Annual Make every Five Years and Maximum Days' Make.

c.ft., and expansion was somewhat slow for ten years after that date, when the make of gas had increased only to 1225 millions, and the whole of the additional capacity required was met by extended use of carburetted water gas plant. As a matter of fact, No. 1 retort house was thrown out of use in 1900, when Nos. 2 and 3 retort houses were fitted with hydraulic stoking machinery and hot coke conveyors. Early in 1914, when the total make of gas had reached 1500 million c.ft. per annum, it was felt that large extensions in the carbonizing plant would have to be made; but the war put a stop to any extensions being undertaken then, and the resources of the Company were strained to the uttermost to maintain the large demand for gas. Three years later the output had increased to over 1800 millions. As soon as it was possible, after the Armistice, plans were drawn for the entire reconstruction of the carbonizing plant in No. 1 retort house, and the enlargement of ancillary apparatus.

The work of extension has been continuous during the past seven years, and has embraced No. 2 section and the carburetted water gas plant as well, the productive capacity of the works now being 8 million c.ft. per day coal gas and 7 million c.ft. per day carburetted water gas.

Fig. 2 is a chart showing annual make every five years and maximum days' make.

No. 1 Retort House.

This house, being derelict, was the first section of the plant which was entirely reconstructed. The size and shape of the house, as designed by the late Mr. J. B. Paddon in 1870, as shown in fig. 3, readily lent itself to the construction of horizontal retorts of large productive capacity. The house is 78 ft. 6 in. wide in the clear—of ample width for long horizontal retorts and modern stoking machinery. It was therefore decided to put in settings of 24 in. by 16 in. ⏢ retorts 23 ft. long; and these were constructed in sets of ten in five tiers. The length of the house accommodated twenty settings, with four chimneys, two of them being taken up as twins in one stack. Regenerative settings were installed, and the plant is capable of producing 4 million c.ft. per day—exactly double the original capacity of the house.

The design of the settings in No. 1 retort house was not found to answer all requirements; and as a result of extended experiments, many improvements were effected when the carbonizing plant in No. 2 retort house came to be reconstructed in 1922. It is a description of this plant which follows; and as there are features of interest and novelty in the design of the settings then installed, it is proposed to give full details.

No. 2 Retort House.

The 4 million c.ft. per day plant consists of two independent sections of 2 million each; each section consisting of ten settings of ten retorts each.

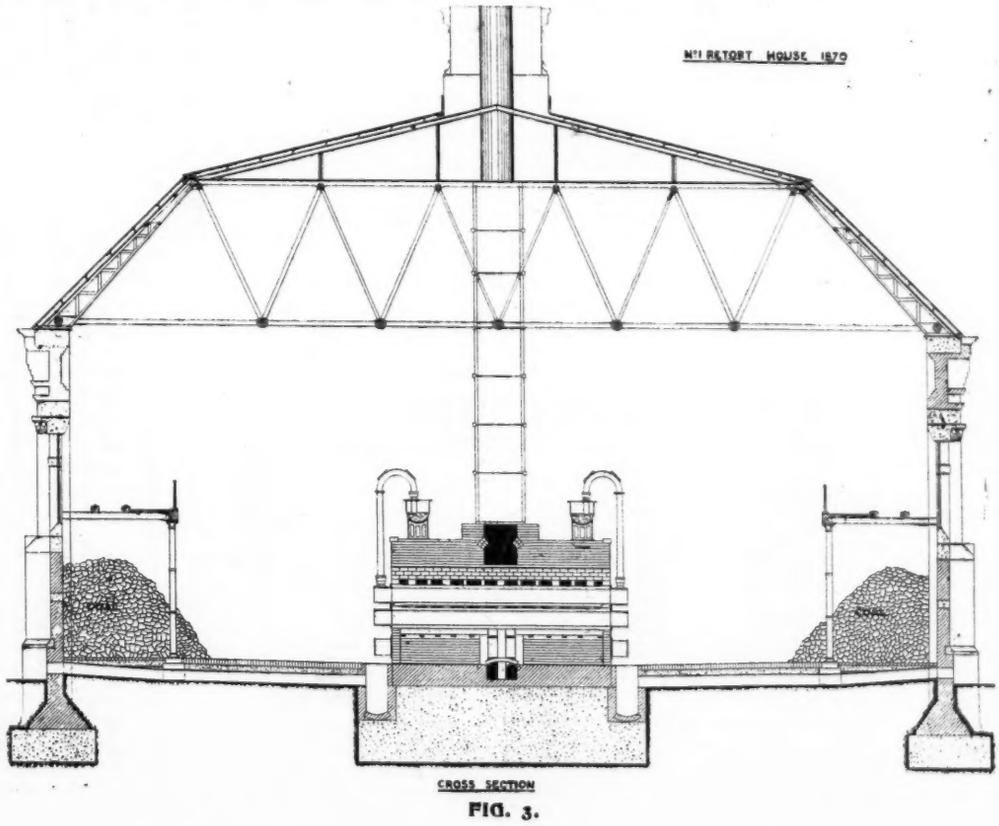


FIG. 3.

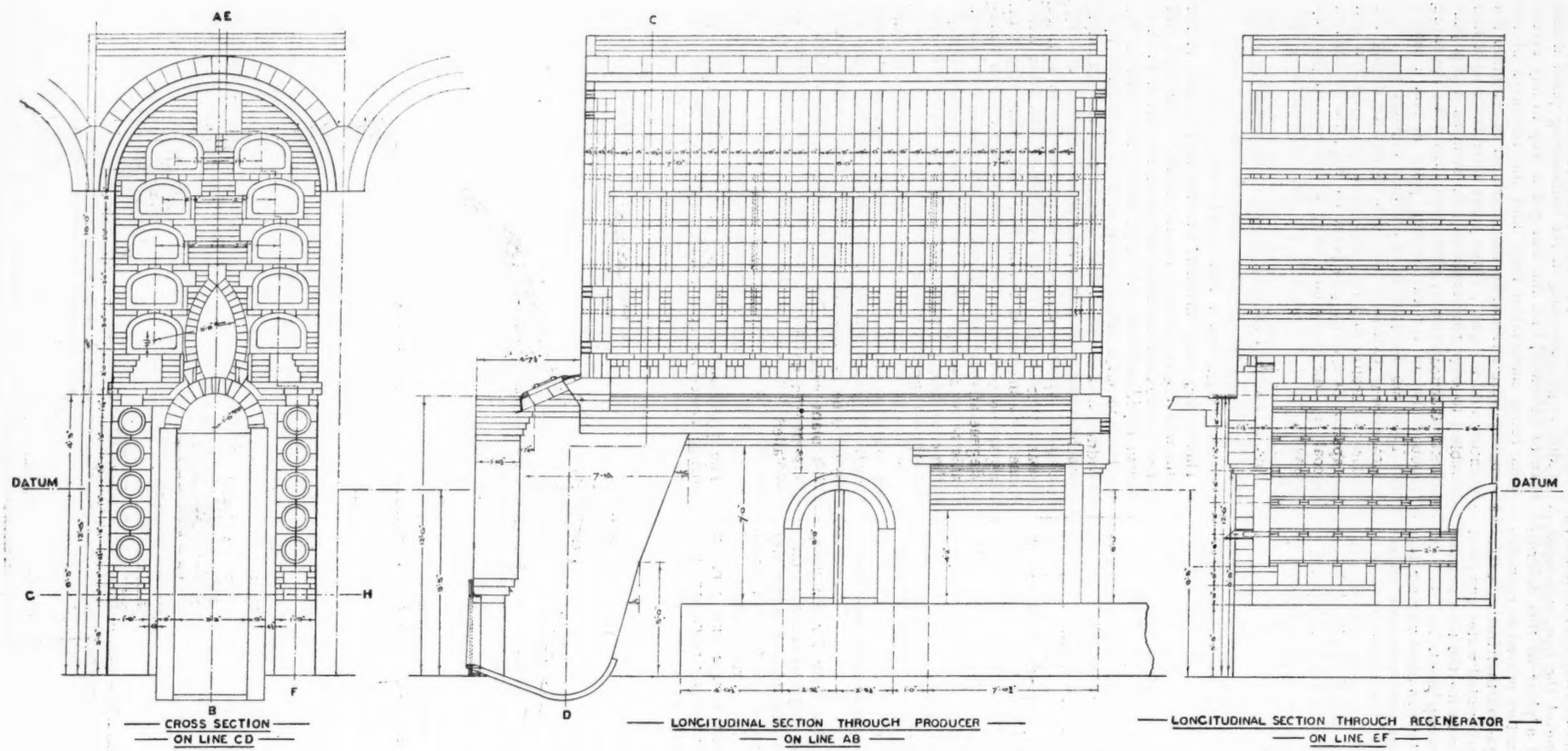


FIG. 4.—No. 2 RETORT HOUSE REGENERATIVE SETTINGS.

The requirements were as follows:

There was to be room at each end of the house to accommodate a stoking machine clear of the benches, in order to facilitate repairs and to avoid masking the last setting.

The retorts were to be the Company's standard size—namely, 24 in. by 16 in. ⏢ 23 ft. long, in settings of ten. Ten settings were to be of moulded fireclay, and ten settings of segmental silica.

Every retort was to have an ascension pipe at each end.

The stage floor and overhead bunkers, with two days' storage, were to be constructed in ferro-concrete.

The retort settings and producers were to be designed with special regard to the following points:

Economy in fuel consumption.

Ease of feeding the producer.

No poking-back or levelling of the fuel bed.

A general plan was then prepared incorporating these special features, when it was found that to accommodate a stoking machine at each end of the house it would be necessary that the dimension between the pier walls of the settings should not exceed 9 ft.

The following is a short description of the plant as evolved and erected:

Main Arches.—These are erected as two benches of ten settings each, the total length of each bench being 114 ft. 2½ in. The pier walls are 1 ft. 10½ in. thick, and not 1 ft. 6 in. as usual, on account of the height of the bench, which is 28 ft. 6 in. from foundation level to top. The end walls are 3 ft. 4½ in. thick, faced with Fletton bricks. Both benches have special large radius blocks

above the inner 9-in. ring of brickwork. One bench has barrel arches with a 6-in. rise in the centre of the springing, and both benches are insulated at the top with a 2-in. course of Moler bricks.

Chimneys.—One chimney is provided to each five settings, measuring 2 ft. 6 in. by 5 ft. internally in plan, the area being based on the well-known rule of 1½ sq. in. to each lineal foot of retort in the settings. The chimneys are lined with firebrick in the usual manner, and faced with Fletton bricks. Each chimney has its own draught regulator situated at the base, which acts as a safety valve in the event of a gale springing up. When waste-heat boilers are installed in this house, these regulators will no longer be required.

Settings.—The retorts of one block of ten settings, shown in fig. 4, attached, are of fireclay (74·4 p.ct. silica) moulded; and it is interesting to note they are of the same composition as those which have withstood such remarkable temperatures at Keighley. They are of the dimensions already mentioned, and when set are spaced vertically 2 ft. from inside bottom to inside bottom. These have square outside corners, a shape which requires very simple blocking. In each 23-ft. through length there are two 7 ft. 6 in. and one 8 ft. length, the joints resting on and being sealed by a 9-in. cross wall. The retorts are shielded from cutting heats by 2-in. tiles of 95 p.ct. silica.

Special attention was paid to the placing of the bottom retorts with a view to efficient heating, which in so many settings is a difficulty. To that end they are placed nearly central horizontally with the centre line of the combustion chamber, and well above the point of ignition. A flue also runs underneath from the back of the setting to the front, carrying the waste gases to the regenerator. The top retorts are staggered inwards, not only to afford clearance for the ascension pipes, but to ensure that there is no constriction of the side flues. All the flues in the setting are progressively enlarged as they pass forward.

The second middles, third middles, and tops have spaces left under them (sometimes referred to as spots) varying in size from 2 in. by 2 in. to 9 in. by 2 in., to allow of some by-passing of the flue gases, to keep the underside of the retorts evenly heated.

The retorts referred to here have been working for 910 days at a somewhat high temperature for fireclay—namely, 1350° to 1450° C.—and at present show no signs of wear. The temperatures are taken daily with a Féry radiation pyrometer, which is frequently calibrated; and no dripping or deterioration has so far been observed.

Cross Walls.—These walls are built of 95 p.ct. silica between the retorts, and of Scotch fireclay outside; there are also special blocks of "Wortley" fireclay fitting round the retorts, to save the expense of cutting bricks. This is a useful and economic method of construction, as there are only three special shapes required; but it fails if the moulded retort lengths are not reasonably straight. In the case of silica segmental retorts, however, this method of construction is ideal, the special shapes (of 95 p.ct. silica) fitting-in without the slightest difficulty—indeed, one experimental setting of silica segmental retorts at Portslade was erected without a single block being cut.

The allowance for expansion in the cross walls where silica is used in the centre only is $\frac{3}{16}$ in to 1 ft., and is made by inserting a sufficient number of "S.X." board strips in the horizontal joints, and leaving loose joints vertically. When raising the heats, the "S.X." board burns out, and the expansion is accommodated without the slightest disturbance to the settings.

The cross walls are carried above the crowns of the top retorts, to afford a substantial resistance to the upward bursting-effect when pushing out a stubborn charge. A space is left in the centre to permit of inspection from the sight plug while working. The cross walls are 6 in. thick (except where the joints in the retorts occur, where they are 9 in., in order to seal them effectually), and the spaces between are 9 in. and 9½ in. The total area of retort surface exposed to the heat is 53 p.ct.

Combustion Chamber.—The combustion chamber, which is of 95 p.ct. silica, is 1 ft. 11 in. wide at the maximum, and 4 ft. high inside; the arch is of the Gothic type with keystone. There are two CO nostrils to each space between the cross walls, and they are situated on adjacent sides of the producer arch keystone, being tapered from top to bottom. The secondary air nostrils are so placed that anything falling from above cannot obstruct the free flow of air. These nostrils are formed from four special shapes, for convenience in manufacture—a point that is sometimes overlooked, causing much inconvenience both to the brickmaker and to the customer, as awkward shapes in 95 p.ct. silica often become distorted in the kiln. Allowance for longitudinal expansion in the lower courses of the combustion chambers is a matter of some moment when it is considered that provision of an aggregate length of nearly 4 in. has to be made. In this case it was allowed for by leaving every alternate joint dry, but an alternative method, and one that can only be used in some places, is to leave a thick joint of silica clay which squeezes out before it is set. The combustion chamber is furnished with two sight-plugs, one at the soffit of the arch, and one in the centre of the chamber, for convenience in inspection; they are of fireclay, and last about a month.

Producer.—The arch is of special fireclay radius blocks, with the keystone and nostrils in 95 p.ct. silica. Allowances for the expansion in the longitudinal length were made by using thick joints. The producer is 12 ft. 5 in. deep from the soffit of the arch to the bottom of the ashpan—a depth which has amply repaid the expense of extra excavation and foundations. The fires will go eight hours without recharging (but in working are charged every four hours), and at the end of the longer period are still giving off gas equal to that of producers 7 ft. 6 in. deep which have been freshly charged. An analysis of gases taken just before coking gives the following results:

CO_2	0·9 p.ct.
CO	19·4 ,,
N	79·7 ,,

The depth from back to front of 7 ft. 6 in. is a precaution against the flame bed becoming obstructed by coke, and it gives additional capacity. The back slopes at an angle of 20° to the vertical to a point 5 ft. from the bottom, where the angle is changed to 15° to the vertical. The idea is to prevent a body of ash collecting near the base of the furnace which cannot be removed without a considerable disturbance of the fire and a consequent loss of good fuel in the ashpan. The grate area varies from 0·5 sq. ft. to 0·8 sq. ft. per 10 ft. of retort in the setting, according to the type of grate installed. Five of the producers are fitted with "Bath" grates, five with a step grate of "Brighton" design, and ten with "Sydenham" grates. Special attention has been paid to the heavy labour normally entailed in coking up, and to that end the producers were extended 4 ft. 7½ in. from the front of the bench, and a special transporter was designed (Drakes' "Brighton" transporter) incorporating a coke shoot, to enable the hot coke to flow freely and easily into the producer. The feeding opening, which is of generous proportions in order to prevent obstruction to the hot coke, is 2 ft. by 1 ft. 8 in. inside, with a special lid of cast iron filled with fireclay tiles. The whole of the producers in No. 1 retort house have been re-modelled on these lines, and it is interesting to observe that the fuel account for the year 1925 was 7·4 lbs. per 100 lbs. of coal carbonized, or, expressed in the more usual form, 1·48 cwt., or 11 p.ct. on the make of 13·5 cwt. of coke per ton of coal carbonized; the balance of 0·51 cwt. being used as boiler fuel. The sale of coke was 11·51 cwt. per ton of coal carbonized. The ashpans are made *in situ* with a 4 : 2 : 1 mixture of concrete, the aggregate being composed of broken retort. After tentative trials with blue brick, firebrick, and clinker aggregate, the broken retort proved to be the best.

Regenerator.—In designing the regenerator, consideration was given to the following requirement: The setting was to be worked with a slight pressure in the combustion chamber; therefore the secondary air could not be drawn into the chamber by draught, and would have to enter at a pressure slightly above the back pressure in the chamber. To attain this object, the principle of the deficiency of weight in a column of rarefied air, or chimney effect, had to be brought into full use, and therefore the secondary air had to rise vertically and with the minimum baffling effect. In order to impart the maximum amount

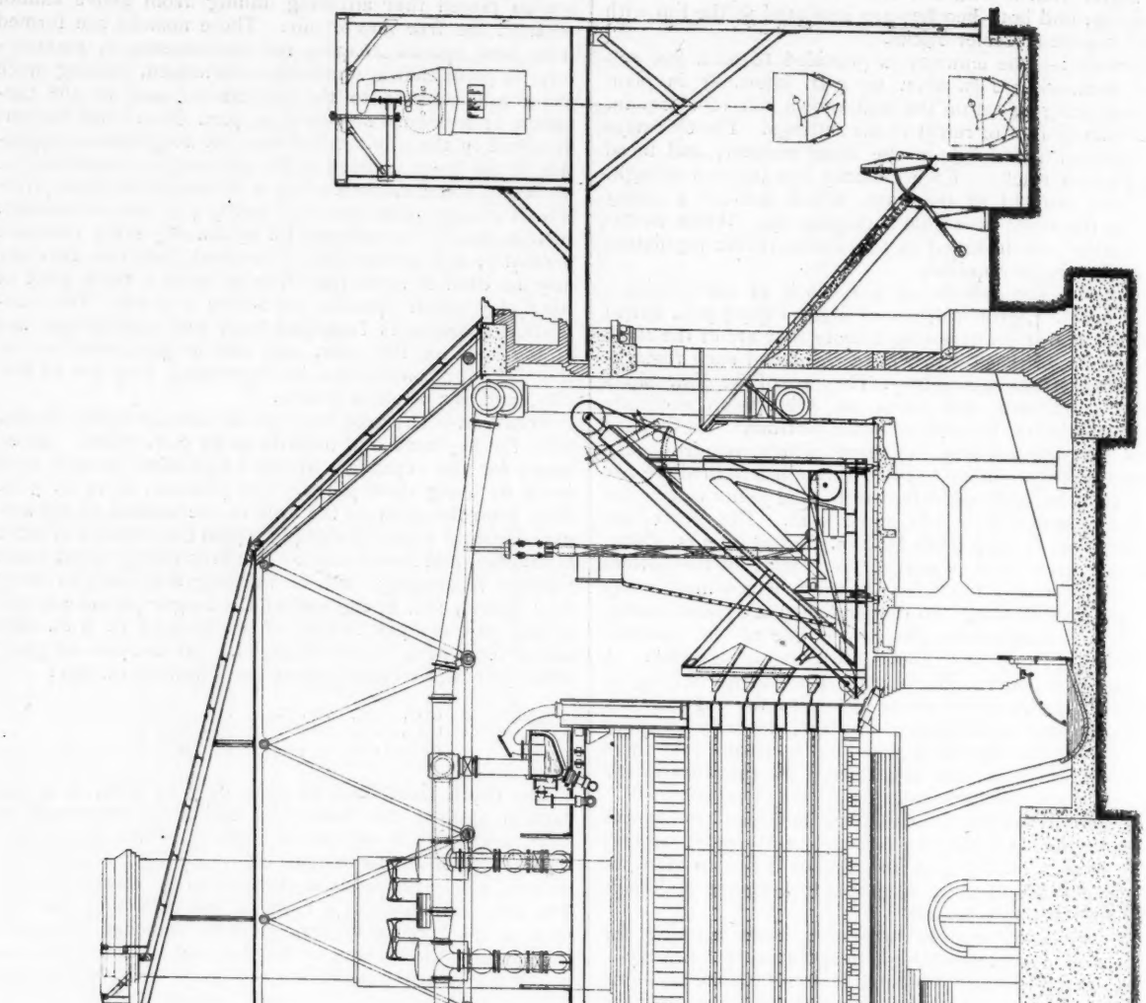


FIG. 5.—No. 2 RETORT HOUSE, 1926.

of heat to the ascending column of secondary air, it was decided that the waste heat must travel horizontally. Tiles were considered as one of the various ways of effecting this, and rejected because only one side of the tile would be available for the transfer of heat, and there was the difficulty of sealing joints to prevent by-passing. It was finally decided to use tubes 11 in. in dia. by 1½ in. thick, because: (1) A round tube has strength; (2) the thickness of the walls can be reduced to a minimum; (3) about one-third of the circumference on both sides—two-thirds in all—is available for the transfer of heat.

There are several patent tubular regenerators on the market, some of them highly efficient; but they are for the most part designed on the principle that the perimeter of a square is greater than the periphery of a circle for a given area, and therefore it is assumed that there is more heating surface exposed. But if the assumption is correct that the secondary air rises vertically with increasing velocity up the sides of the tubes, then the underside and upper side of a square fulfils no useful purpose in the transmission of heat.

It is sometimes thought that it would be more advantageous to do away with regenerators, and recover the heat by means of waste-heat boilers. But a simple calculation will show one that however efficient a regenerator may be, there is plenty of heat available both for regeneration and waste-heat boilers. A black main flue leads to the supposition that the regenerators are doing their work most efficiently, but this is often a mistake. The ingress of cold air through ill-fitting sight-plugs and dampers is the insidious enemy, as an examination of the CO_2 content of the gases in the main flue will show. The following are some CO_2 content figures, with the corresponding dilution they represent:

CO_2, P.Ct.		Dilution, P.Ct.
19·2	..	*Nil*
16·6	..	25
14·6	..	50
11·8	..	100
9·93	..	150
8·55	..	200

All-Silica Settings.—These are of a similar size and design to the moulded fireclay retort settings, the only difference being the use of segmental silica retorts in place of the fireclay retorts, the shield tiles being omitted. These settings have not been sufficiently long in use and under observation to allow of any useful information concerning their working being given on this occasion. It may, however, be stated that an experimental setting has been at work for a considerable period, and has given excellent results.

Ascension Pipes and Mouthpieces.—It was intended to have the ascension pipes 7 in. internal diameter, but they had to be reduced to 6½ in. internal diameter to pass them up between the mouthpieces. The centre lines of pipes are 1 ft. from the front wall of the setting, which is 1 ft. 3½ in. thick, and contains 2 in. of Moler insulating brick, to minimize the nuisance from stopped pipes, which, however, are not very frequent at Portslade. The mouthpieces and lids are of several different patterns, and are attached to the retorts by the loose socket method. All are fitted with the same type of automatic catch. The bridge pipes are of the "Bournemouth" type.

Hydraulic Mains, &c.—The hydraulic mains are independent units, two to each setting, with separate gas off-takes, tar and liquor pipes, and seal regulator. Special care was taken to ensure all the dip pipes being level. The seal regulator is efficient and inexpensive. It can be readily inspected and cleaned, whereas a weir valve is comparatively costly, and is unreliable when fine regulation is required. The tar towers, which are constructed from old hydraulic mains, have a weir valve at the top which acts as a master valve to the seal of each of its five hydraulic mains, it being set ⅝ in. lower than the seal regulators on the latter.

Governors.—Two of these are erected on a platform at one end of the house, and reached by a short flight of steps from the stage floor. They are more readily attended to in this position than in the usual place, on top of the setting. They are of the Carpenter type, and no disadvantage has been experienced in having them some distance from the hydraulic mains they govern.

Stage Floor.—Fig. 5 shows a cross-section of the settings, and the general arrangement of apparatus in No. 2 retort house, and illustrates how well the original design of the house accommodates the enlarged plant without any alteration to walls or roof. On each side of the settings is a stage floor, constructed in reinforced concrete, on the indented bar system. This method of construction has been found satisfactory where ample depth has been given to the supporting beams. This is most essential where heavy modern stoking machinery is to be accommodated.

Coal Bunkers.—Overhead coal bunkers are constructed in reinforced concrete, supported on reinforced concrete beams and columns, and on the extended buckstaves on the charging side. The beams are not attached to the buckstaves in any way, but are allowed to slide on a convex shoe attached to the top of the buckstave. This method of construction was adopted so that any movement of the buckstave should not be communicated to the concrete beam. The bunkers are nine in number, constructed between the main roof principals, and have a total capacity of 750 tons, sufficient for two days' working.

There are two charging machines in each retort house—a Guest-Gibbons and a central-chain Fiddes-Aldridge. The latter machine is speedy and reliable; and, with the improvements effected in it by eliminating undesirable features—ascertained after continuous practical working under severe service conditions—it is a most efficient machine, which spreads an even charge with no hills and valleys, and consequently produces more regular carbonization of coal.

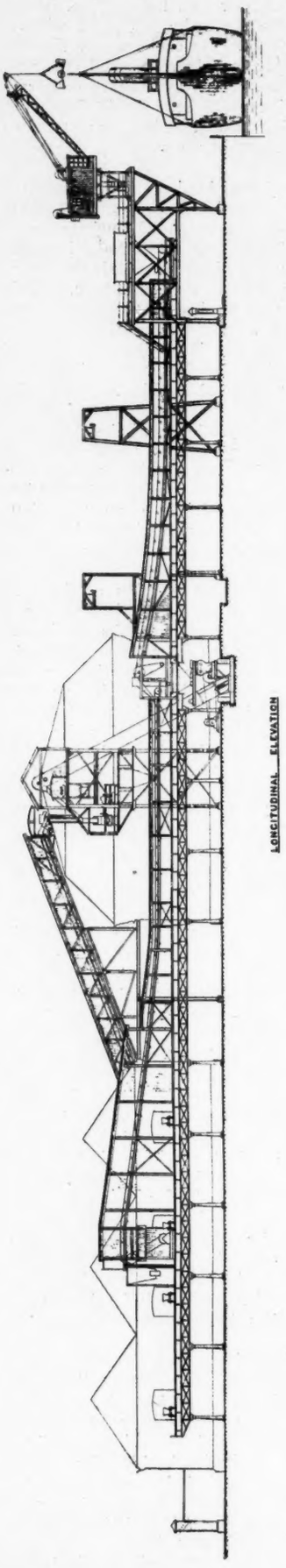
Coal Handling Plant.—The reconstruction of the carbonizing plant necessitated an entire reorganization of the coal handling plant as originally installed. As previously mentioned, the coal brought by sea from Tyne ports was discharged by means of steam cranes elevating at the rate of 25 tons per hour in small skips, and it was then transported along the low-level gantry to the retort house and coal stores in hand-pushed trucks. Under the new conditions, it was necessary to raise the coal to such a height that it could be fed into the overhead bunkers in the retort house, and be conveyed to the coal stores in the rear. The plant also had to be large enough to handle the coal ultimately required for both retort houses—namely, a quantity averaging 700 to 800 tons per day.

An elevated steel gantry was constructed to support two 3-ton electric cranes, as shown in fig. 6. The design of the gantry-head had to provide full scope for the swing of the cranes over the steamers, but at the same time it had to avoid placing any undue weight close to the edge of the wharf, which is not of particularly substantial construction. The cranes are of Messrs. Stothert & Pitt's manufacture, with the Toplis patent luffing gear. They have a radius of 33 ft., and discharge the steamers by means of 1-ton Adams' grabs, designed and made on the works, at the rate of 90 tons per hour, depositing coal on the grid of a 60-ton steel hopper erected on the deck of the elevated portion of the gantry. From this hopper the coal is fed on to a rubber and canvas belt conveyor of 90 tons per hour capacity, which carries it along to the coal breakers, constructed between the retort houses, each breaker being capable of dealing with 45 tons per hour. From the breakers the coal drops into the boots of two elevators, which lift the coal to the level of the extreme top of the retort house, discharging on to a short cross belt, and thence on to the main belt running the entire length of the retort house, from which it is thrown off into any desired coal bunker by means of a movable carriage.

The same conveying, breaking, and elevating plant supplies the needs of No. 2 retort house in a similar manner by means of adjustable slides in the elevator discharge chutes. The main conveyor, on its passage from the gantry-head, passes over a Blake-Dennison weigher, which is found of very great utility in checking the weight of coal received by ships. The main belt conveyor, of the North British Rubber Company's manufacture, has conveyed upwards of 600,000 tons of coal; and though it is now beginning to show signs of wear, it is safe to prophesy a life of 1 million tons for it, the edges only being slightly frayed from touching the guiding idlers.

By means of suitable slides, the coal can be diverted

FIG. 5.—No. 2 RETORT HOUSE, 1926.



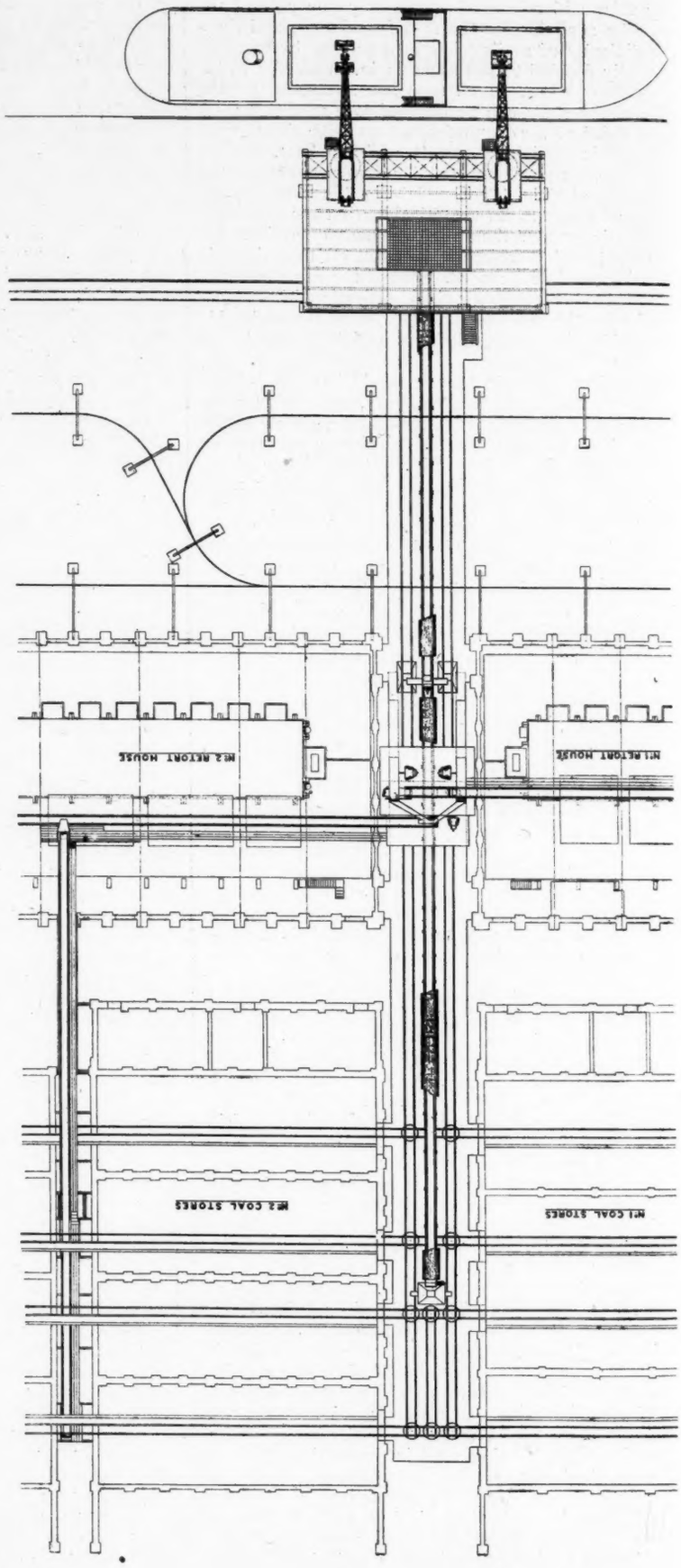


FIG. 6.—COAL-HANDLING PLANT.

from falling into the breakers, and discharged instead on to another conveyor for transport to the coal stores. This is accomplished by continuing the conveyor along the gantry for discharge into a small overhead hopper holding about 10 tons of coal. This has three outlets from which the coal can be fed into hand-pushed trucks holding 10 to 12 cwt. each. These trucks pass along narrow gauge tramways traversing the stores, and the coal is then emptied into the various bays by striking the bottom doors of the wagons. For emptying the coal stores, some small steam cranes are used to lift skips holding 6 cwt., which empty into the before-mentioned hand-pushed wagons. These are taken to the elevators on the main gantry, or are discharged on to the auxiliary conveyors, which convey and elevate the coal to the top of the respective retort houses, where it drops on to the main band for feeding the bunkers. These conveyors—all of the rubber covered canvas belt design—rise at an angle of 20¾° from the horizontal, this angle being the limit of the useful employment of a belt conveyor, any steeper gradient resulting in the rolling backwards of the larger lumps of coal.

It will be noticed from the drawings that it has been possible to utilize the original gantry, extending from the water side to the rear of the coal stores, for accommodating much of the coal handling plant.

The transport of coal for No. 3 retort house will be accomplished along the same conveyor which now feeds the bunkers in No. 2 retort house, as it will be necessary only to instal an additional band conveyor as an extension of the existing conveyor.

The extensive use of band conveyors has been fully justified in the satisfaction which they have given. They take the minimum power for driving of any class of conveyor. They are smooth running and noiseless, and, as mentioned in connection with the coal stores conveyors, they can be elevated to an angle of 20¾° without detriment to their carrying capacity. The fact that they will transport a quantity of a million tons of coal during their lifetime, with no repairs or attention except the ordinary lubrication of the rollers and idlers, is a recommendation greatly in their favour. It is most essential, however, that every care should be taken in the alignment of the band, so that it runs absolutely true on the idlers.

The following particulars relating to the horse-power used in the various operations of the coal handling plant have been compiled from careful observations made at the Portslade Works. Many of the motors have an excess of power over requirements; but it was considered an economy to instal, where possible, motors of similar make and power, to avoid stocking so many different spares.

Coke Plant.—The coke, on being pushed out by the charging machine, is received on a Drakes' transporter, which lifts and discharges it through the old windowways of the house on to the inclined quenching bench outside the retort house. The same machine as previously described is utilized for filling the producer by means of a chute which can be folded-back into the body of the machine when the skip is being used for discharging the coke on to the quenching bench (see fig. 7). This method saves the usual cumbersome coke 'bus, and ensures a clearer discharging floor; and there is one piece of machinery less to maintain. One transporter attends on each charging machine. After quenching on the inclined bench, the coke is allowed to slide into skips holding about

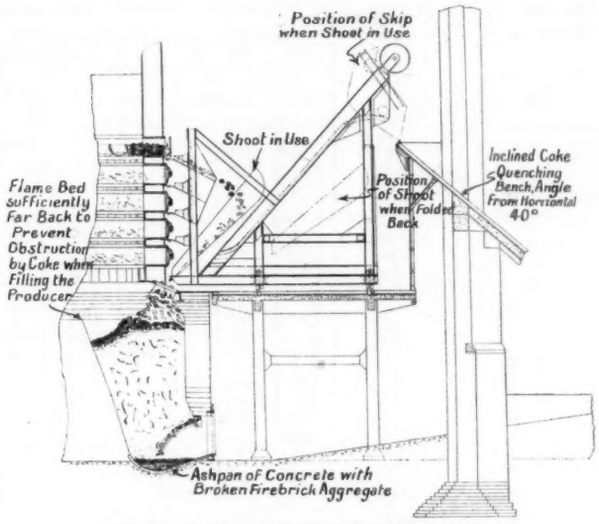

Position of Skip when Shoot in Use
Shoot in Use
Inclined Coke Quenching Bench, Angle from Horizontal 40°
Position of Shoot when Folded Back
Flame Bed sufficiently Far Back to Prevent Obstruction by Coke when Filling the Producer
Ashpan of Concrete with Broken Firebrick Aggregate

Fig. 7.—Producer and Feeding Arrangements.

15 cwt., and is removed by telpher machines to any part of the coke yard, to the lorry and sack loading hoppers, to a "Whitehall" screening plant, to the coke bunkers supplying the carburetted water gas plant, or to the boiler houses at the extreme western end of the works. The arrangement of the telpher track is shown in fig. 8, which is a general plan of the works.

Breeze Plant.—The separating plant for the breeze consisted of a rotary screen set at an angle of 15°, into which the pan breeze was tipped after the removal of the larger pieces of clinker. The screen separated the breeze into four grades; the two larger kinds being used under the steam boilers, and the fine pan ashes and second size being sold for garden paths and other purposes. During the war a very large quantity of unsifted pan breeze was accumulated in a dump on some waste land belonging to the Company to the east of the works, and it was necessary to make some arrangement at that spot for screening and grading it. A full-sized "Columbus" screening plant was erected, and disposed of an accumulation of breeze of 10,000 to 15,000 tons in two years, in a perfectly satisfactory manner. The principle of the plant is the well-known flotation method, and from the breeze were recovered 45 p.ct. of coke, 35 p.ct. of clinker, and 20 p.ct. of ashes. The recovered coke was used

FIG. 6.—COAL-HANDLING PLANT.

Coal Handling Plant—Electric Motors.

Plant.	Work.	Make of Motor.	Winding.	Nominal B.H.P.	Amperes Used.		Actual H.P. Used. Loaded.
					Light.	Loaded.	
3-ton cranes	Grabbing and hoisting 45 tons per hour. Grab weighing 28 cwt., and lifting 1 ton of coal at the rate of 180 ft. per minute	Westinghouse	Series	50	90	160	47·1
,,	Slewing	,,	Compound	6	20	25	7·3
,,	Luffing	,,	,,	6	15	30	8·8
Wharf conveyor	Conveying 90 tons of coal per hour. Length, 133 ft. centres	General Electric Co.	Shunt	15	10	22	6·4
Extension conveyor	Conveying 90 tons of coal per hour. Length 170 ft. centres	,, ,, ,,	Compound	15	20	35	10·3
Coal crushers	Crushing 45 tons of coal per hour	,, ,, ,,	Shunt	15	12	36	10·6
Elevators	Elevating 45 tons of coal per hour. Height, 55 ft. centres; 86 buckets	,, ,, ,,	,,	15	25	47	13·8
Retort house conveyors	Conveying 90 tons of coal per hour. Length, 280 ft. centres	,, ,, ,,	,,	15	15	25	7·3
Coal stores conveyors	No. 1, 193 ft. 6 in. centres (part at 22½°). No. 2, 186 ft. 9 in. centres (part at 20¾°). Conveying 90 tons of coal per hour	,, ,, ,,	,,	15	20	40	11·8

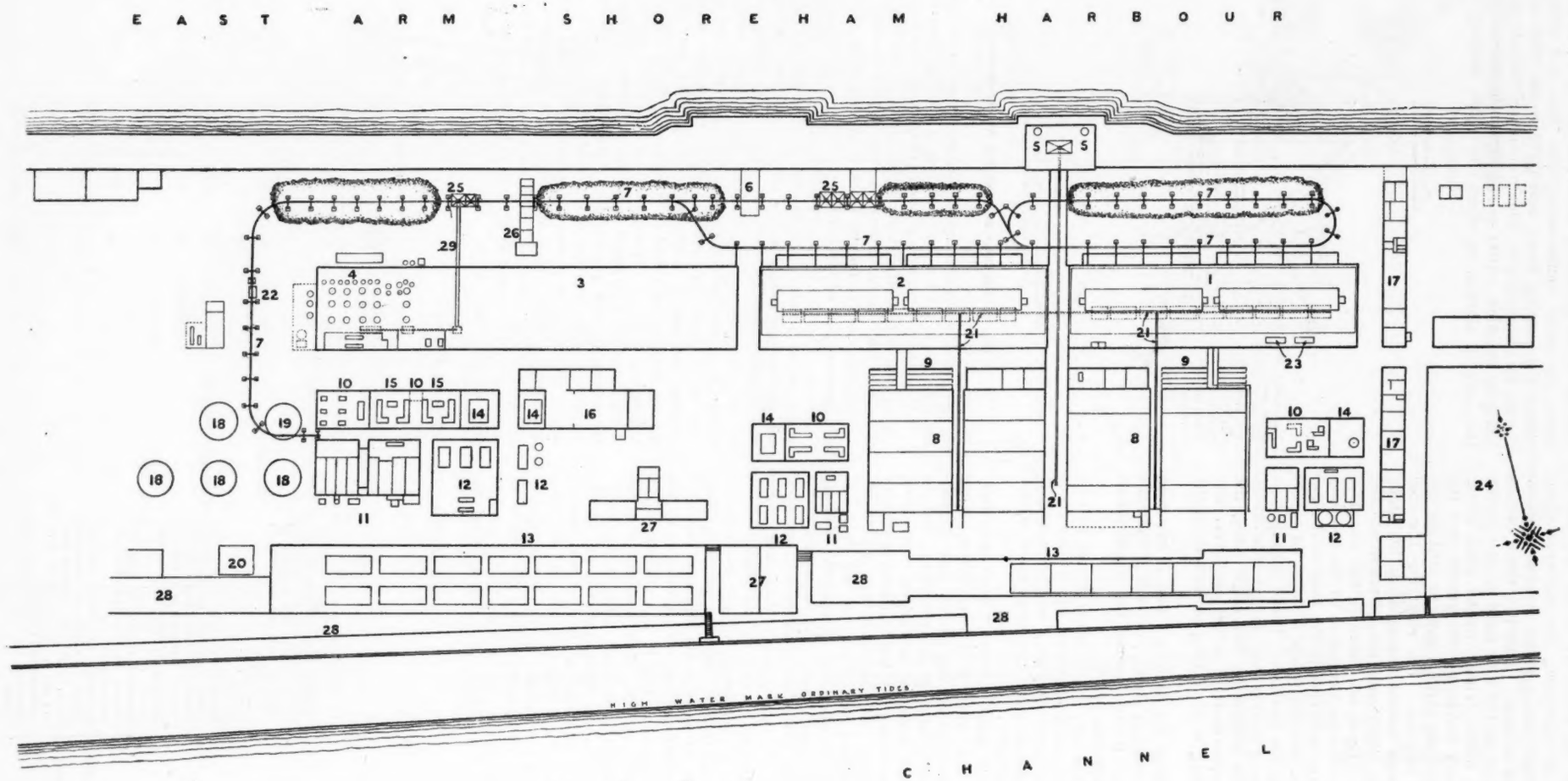


FIG. 8.—PLAN OF WORKS, 1926.

REFERENCE TABLE.

1.—No. 1 Retort House.
2.—No. 2 " "
3.—No. 3 " "
4.—C.W.G. Plant.
5.—Electric Cranes.
6.—Weighbridges.
7.—Telpher Track.
8.—Coal Stores.
9.—Condensers.
10.—Engine Houses.
11.—Boilers.
12.—Washers and Scrubbers.
13.—Purifiers.
14.—Meter Houses.
15.—Electrical Generating Plant.
16.—Machine Shop.
17.—Offices, Stores, and Laboratory.
18.—Oil Tanks and Gasholder.
19.—C.W.G. Cooling Tank.
20.—Laundry.
21.—Coal Conveyors.
22.—Columbus Breeze Washer.
23.—Waste-Heat Boilers.
24.—Recreation Ground.
25.—Coke Bunkers.
26.—Whitehall Screen.
27.—Canteen.
28.—Oxide Ground.
29.—Coke Transporter.

under the steam boilers in the usual way. When the accumulation of breeze at the east end of the works had all been dealt with by the screen, it was dismantled and re-erected at the west end of the works for recovering the current make. The breeze, as removed from the producers by the firemen in the retort houses, is tipped into the boot of a small bucket elevator, which raises it to the level of the inclined coke bench and deposits it on a bay specially reserved for it. From the coke bench it is discharged into the telpher skip for removal to the separating plant. Here it falls on to a screen for separating out the larger lumps; the seconds falling into a hopper to be fed into the "Columbus" plant. This method of dealing with the breeze has saved a considerable amount of cartage about the works, as the separated coke can be conveyed direct to the boiler houses.

Carburetted Water Gas.—As soon as possible after the armistice, the extension of the carburetted water gas plant (which until then had not been possible, owing to the war-time restriction on the use of steel plate) was pushed forward with all possible expedition; and by the end of 1919 the fifth complete set, with a manufacturing capacity of 2 million c.ft. per day, was installed. Additional steam raising plant was also erected to meet the greater demand, and the nominal capacity of the plant as a whole was increased to 7 millions a day. During the current year, waste-heat boilers in connection with the plant are being installed to take the place of some of the older Lancashire boilers which have been in use for a good many years; and it is proposed gradually to make the carburetted water gas plant self-supporting, as far as steam is concerned, with the provision of waste-heat boilers for each of the five sets.

Ancillary Plant.

The description of the carbonizing plant, with its feeder, the coal handling plant, has occupied such a large proportion of this paper that the author feels he must give only a cursory review of the ancillary plant which has been installed at the Portslade Works during the past few years.

Electric Generating Plant.—With the introduction of modern high-speed retort charging machinery and the decision to instal electric cranes, it became a necessity to provide electric generating machinery, which, moreover, had to be of sufficient capacity to supply the power which was likely to be required throughout the works for many years to come.

The electrical plant at Portslade consists of duplicate sets of Browett-Lindley inverted vertical compound steam engines of 365 H.P., each driving a General Electric Company's dynamo of 250 KW. capacity, producing direct current of 220 volts. Each set can generate 1135 amperes; and they can be worked, if necessary, in parallel for very heavy loads. Hitherto, one set at a time has been amply sufficient to generate all the electricity required for the various works motors. These include all in connection with the charging and discharging machinery, the electric cranes, the coal handling plant, the coke and breeze handling plant, pumps, wood-working machinery, and other uses. When all the motors are at work simultaneously, the total demand on the plant is 187 KW.; but new uses are constantly being found for the electric power, and it is satisfactory to feel that there is an ample surplus.

The boilers which supply the steam for driving the electrical plant are fed entirely by coke breeze and recovered pan breeze, so that the production is economical and cheap. As a stand-by in case of the breakdown of the steam plant, or while repairs are being effected on any of the cables, a five-cylinder "Hindley" gas engine has been installed in the basement of No. 1 retort house; and this drives a Siemens 90-KW. dynamo with the same voltage as the larger machines. This is of sufficient capacity to work the retort house machinery; and the plant is often used at night or on Sundays when one of the larger sets is unnecessary.

The steam-driven sets are erected in No. 3 exhauster house, where there is ample floor space to accommodate them. Here, again, the wisdom is exemplified of making all buildings of larger capacity than is required for the plant immediately to be installed, as in subsequent years it is so often necessary to enlarge existing plant or provide larger apparatus. When No. 3 engine house was designed in 1890, it was never anticipated that it would be used for anything except the exhausting machinery then installed; but its ample size easily accommodated the additional plant erected thirty years later.

Exhausting Machinery.—No. 1 engine house contained, until last year, what was believed to be the oldest exhausting machinery in existence. It consisted of a beam engine driving by belt a reciprocating exhauster designed and erected by Messrs. Burton, Sons, & Waller in 1865, at the old Hove Works. Fig. 9 illustrates a photograph of this machinery taken just before its demolition. The engine was still doing excellent work; and it is believed that with a new cylinder its life could have been extended for another few decades. But the exhauster was barely up to its rated capacity of 80,000 c.ft. per hour; and it had to make place for a modern piece of apparatus. This was a Donkin exhauster of a capacity of 200,000 c.ft. per hour, with a direct-coupled steam engine of 36 B.H.P. In the previous year a Waller exhauster of 200,000 c.ft. per hour capacity had taken the place of a smaller exhauster, direct-driven by an engine which had been removed from the Black Rock Works in 1886, and which is still giving excellent service.

The two exhausters mentioned take the gas from the retorts through the various purifying apparatus, and deliver it at the inlet of the station meter at a pressure of

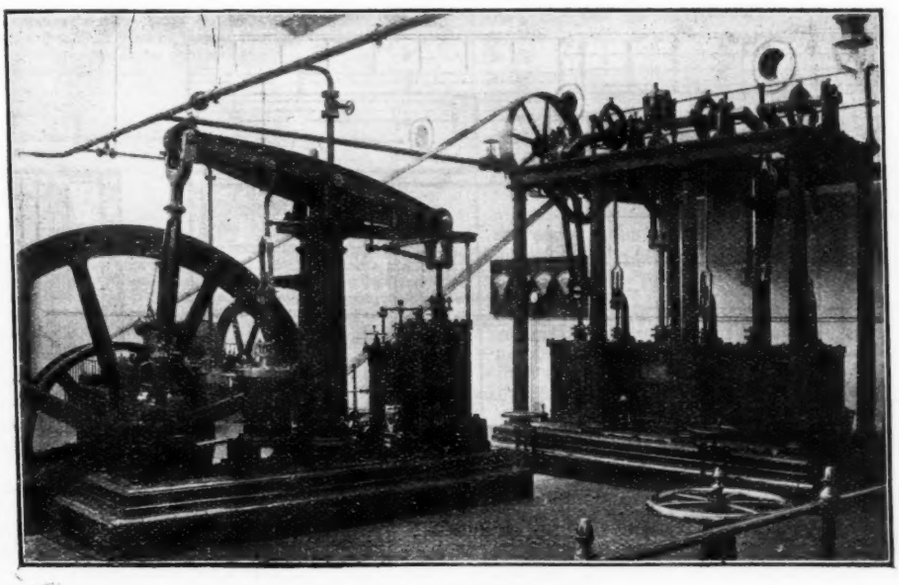


FIG. 9.—BEAM ENGINE.

about 4 in. water gauge. On the outlet of the station meter there are other exhausters, for boosting the gas to the holder stations at Hove and Black Rock. This plant consists of two of Waller's exhausters—one of 125,000 c.ft. per hour capacity, and the other of 200,000 c.ft.—installed this year.

In connection with exhausting machinery, in the author's opinion too little consideration is given to the size of the flywheels and the stroke of engines driving exhausters. In modern practice, the stroke is short, the flywheels are small, and usually two are provided. It is admitted that this method may contribute to steadying a quick-moving machine; but a long stroke with one large flywheel situated between the engine and the exhauster is to be preferred when heavy work has to be performed, the momentum of the large flywheel having a great effect in carrying the engine over the dead centre.

Condensers.—In No. 1 section, the doubling of the capacity of the carbonizing plant rendered it necessary to enlarge correspondingly both the wet and the dry purifying plant. In the case of the condensers, it was decided to utilize a considerable length of 18-in. foul main which had been thrown out of use in No. 3 retort house. This consisted of steel flange pipe; and it was re-erected last year in the form of an atmospheric condenser, supported on the walls of the coal stores. A steel tray was provided underneath the bottom line of the range, to act as a container for the cooling water, which was fed on to the top line of pipes by means of a continuous spray. The condensing surface of the original atmospheric condensers was doubled, and the installation has proved satisfactory.

Washers and Scrubbers.—As mentioned in the early part of the paper, the rotary scrubbers in use at Portslade were originally designed by the late Mr. J. B. Paddon, and all of them are still in use. The capacity of those in No. 1 section is strained to the utmost with the larger make of gas. It is therefore intended, during the current year, to instal two additional vessels of similar design, on some spare ground at the east end of No. 1 purifying house; and when these have been brought into use, the old scrubbers will be reconstructed, or new vessels put in their place. In spite of their sixty years' service, the old scrubbers are still doing useful work, and with complete overhaul and renovation may last another twenty or thirty years. The washers of the Livesey type are very efficient, but not now being of sufficient capacity they will be replaced by larger vessels during next year.

Purifiers.—The nine old water-lute purifiers, each 36 ft. by 18 ft. by 5 ft. deep, comprising the purifying plant in No. 1 section have been removed and their place taken by seven luteless purifiers each 30 ft. by 40 ft. by 6 ft. deep, the two last boxes acting as catches. The purifiers are constructed in the usual method, in one continuous line with partition plates between each. Continuous traversing rails are laid along the top of the range for the passage of the double traveller for lifting the lids. The interiors of the boxes are constructed without supporting columns, except along the middle gangway; the side and transverse galleries being supported by brackets bolted to the side and partition plates, as shown in fig. 10. By this method a much larger area is obtained inside the boxes for purifying purposes, and the arrangement of the grids is simplified.

The inlet and outlet valves are of the Milbourne duplex reversible disc type, except in the case of the two catch boxes, where they are of the gate type. All the connections throughout No. 1 section are 24 in. in diameter; and at every opportunity the old 16-in. pipes are being exchanged for the larger size.

Station Meters.—These, throughout the works, were originally of ample capacity to deal with large makes of gas; but in No. 1 section a rotary meter has been added to the other equipment, and at present it is arranged to work either in series or in parallel with the old station meter.

Trunk Main.—With the constantly increasing output of gas, it has been necessary to put in a new trunk main from the works to Hove, a distance of almost 2 miles. In 1870, when the works were erected, a 16-in. main sufficed to carry the gas from the works to the gasholder station. In 1880 a 24-in. main was added. Last year a new 24-in. main was laid along the same line as the other two mains. It was not carried right up to the Hove gasholder station, but connected with a 20-in. main which carries the gas from the Hove holders to the Black Rock holders, thus acting as a conveyor of gas to either gasholder station as required.

Cost of Work.—The accompanying schedule appended gives approximately the cost of more recent alterations and additions. It was thought that to give only the immediate post-war cost of the reconstruction of No. 1 retort house would not be of any particular interest or service to the members; and therefore the cost of the plant installed during the last two or three years is stated, wherever it has been possible to do so.

In conclusion, the author wishes to express his grateful acknowledgments of assistance in the preparation of this paper from Mr. H. V. Corfield (member), Assistant Engineer of the Company; Mr. G. Le B. Diamond (associate member), and Mr. E. A. Harmes (associate member), the author's Engineering Assistants, for the preparation of drawings—the former being responsible for the detailed design of the carbonizing plant—and from Mr. A. A. Yeomanson, Statistical Clerk, who supplied the schedule of costs. Acknowledgment has already been made of the permission of the Institution of Civil Engineers to use information and drawings from the late Mr. J. B. Paddon's paper.

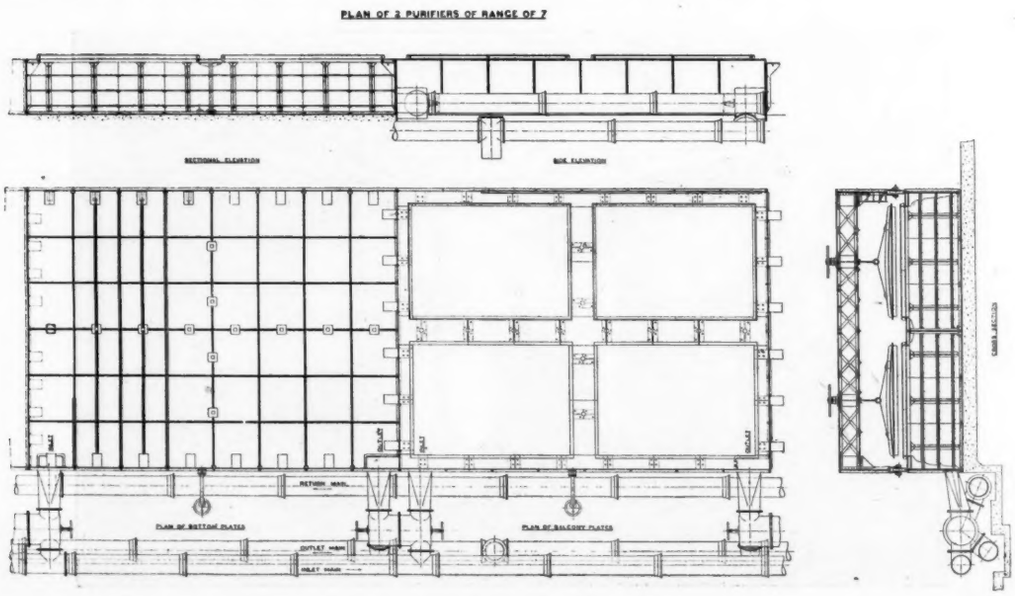


FIG. 10.—PLAN OF PURIFIERS.

APPENDIX.

SCHEDULE OF COSTS.

(1) *A complete block of ten settings of horizontal retorts, consisting of ten through arches, each containing ten 24 in. by 16 in. retorts 23 ft. long, with coal bunkers and stage floors, as constructed in the west end of No. 2 retort house, Portslade. Total number of retorts 100, and of mouthpieces 200. Coal carbonized per diem 148 tons.*

(*a*) *Firegoods*—

	£	£
Retorts. 1840 ft. run fireclay		
230 ,, silica (segmentals)		1,912
230 ,, ,, (moulded)		
Other firegoods		7,409
		9,321

(*b*) *Ironwork, &c.*—

	£	£
Bracing (steel joists and ties)	1458	
Mouthpieces and loose sockets	1344	
Ascension, dip, and arch pipes	1423	
Hydraulic and foul mains	769	
Platforms (for governors and tops of settings)	200	
Governors	264	
Valves and tar cocks	263	
Furnace doors and frames, chimney draught regulators, covers for tar towers, channelling, &c.	502	
		6,223

(*c*) *Reinforced Concrete Work*—

Floors, columns, beams, and coal bunkers (including labour)	4,414

(*d*) *Sundries*—

Cement, lime, timber, pipes and fittings, small castings, blue bricks for floors, iron, steel, bolts, cleaning boxes, &c.	2,572
	22,530
(*e*) Labour on all work, except reinforced concrete floors, columns, beams, and coal bunkers	8,018
	£30,548

Costs—	£
Per mouthpiece	152
Per million c.ft. per diem	15,274
Per ton of coal carbonized per diem	206
Per mouthpiece, settings only, omitting floors and bunkers	130

Memo.—The reconstruction of No. 1 retort house was executed in 1919 and 1920, during the period of high cost of material and labour. The plant consisted of 200 retorts, or 400 mouthpieces, of exactly similar size and length as those installed in No. 2 retort house, together with the steel bracings, retort mountings and fittings, governors, hydraulic mains, foul mains, stage floors, and coal bunkers—all as in No. 2 house. The total cost was £75,648, or £189 per mouthpiece. The difference of £37 per mouthpiece between the cost in No. 1 section and No. 2 section for similar work represents the fall in prices which took place in the years 1922 to 1924, compared with the prices paid in 1919 and 1920. All the work in No. 2 section was done by direct labour, except the reinforced concrete.

(2) *Coke Bench—No. 2 Retort House.*

	Western Half. £
Steelwork	607
Reinforced concrete work	254
Excavating for trench in front of bench, and fixing castings, steel, and preparing for concreting	92
Channel and cast-iron plates	55
Blue bricks	68
Castings	17
Timber	30
Sundries (earthenware pipes, iron, steel, pipes and fittings, &c.)	107
Wages	170
	£1400

Memo.—The coke quenching bench, No. 2 retort house (erected 1923–24), is constructed in reinforced concrete with steel quadrant doors controlled by counterbalanced levers. The upper sloping surface is covered with blue bricks, and the brick piers between the window-ways are also shielded with blue bricks. The total length of the bench is approximately 260 ft., and the length above scheduled 130 ft.

The cost, including steel reinforcement, concrete, blue bricks, doors, fittings, trenching, and all labour for the half length was £1400, or approximately £10 15s. 6d. per ft. run.

(3) *Telpher Extension to Nos. 3 and 4 Boiler Houses.*

Steel trestles with 951 ft. of trackway.

	£
(*a*) Contract price	5428
(*b*) Company's work	76
	£5504

= £5 15s. 9d. per ft. run.

(4) *Purifiers in No. 1 Section (Erected 1925 26)*

	£	£
(*a*) Contract prices		18,504
(*b*) Materials supplied by the Company—		
Cement	253	
Pipes and fittings (24 in.)	214	
Castings	86	
Timber	17	
Wheels	19	
Valves, &c.	21	
Sundries	51	
		661
(*c*) Wages paid by the Company		1,148
		£20,313

Memo.—There are seven boxes of the luteless type, 40 ft. by 30 ft. by 6 ft. deep, with three tiers of shelves. Each box has four covers, and a double traveller runs on rails laid along the top of the range. The connections are 24 in. in diameter, the valves for five of the boxes being of the Milbourne disc type, and for the two catch boxes of the ordinary gate type. Total cost, with connections and 24 in. main from the outlet of purifiers to the inlet of meter, a distance of 136 yards, was £20,313.

Costs—	£	s.	d.
Per purifier	2900	0	0
Per sq. ft. of purifier	2	8	4
Per sq. ft. of purifying surface	0	16	0

Discussion.

The PRESIDENT: The paper is now open for discussion. Mr. Rutter will be pleased to give any information about the drawings which he has been kind enough to prepare for the use of this meeting; and I expect that the more questions put to him, and the greater the bombardment he receives as the result of the presentation of this paper, the more he will be gratified. It bristles with points everywhere, and there are in the room, I know, many members with exceptional experience in regard to horizontal retort working. We shall be glad to hear from them for our mutual benefit.

Mr. W. M. CARR (Stretford): I am very pleased to have an opportunity of congratulating Mr. Rutter on a very useful and practical contribution. It is particularly interesting to me in view of the fact that recently I have carried out work on similar lines. I think I might have improved some of my work if I could have had the benefit of hearing Mr. Rutter's paper three years ago, because we all find on these occasions that, however well we may think we have done our own particular job, when somebody else does a job of work there is always something they can do better than we have done. The paper contains many interesting points; and one which I think is of great interest to all of us at the moment is that Mr. Rutter very wisely decided, in installing his plant, to put down half his retorts in moulded fireclay and half in segmental silica. The question of the use of moulded fireclay or segmental silica for horizontal retorts is a burning question with us all at the present moment; and unfortunately we have not had silica in use for a sufficient period to enable us to know if we are going to get the life from it that has been obtained with the best moulded fireclay. It will be very interesting to learn at some future date what is the experience at Brighton in this respect.

Mr. Rutter says there are no shield tiles in segmental silica retorts. In the installation which I put down, I also have no shield tiles; but in spite of the fact that our refractory materials research—which is of great benefit and which helps us very much—practically shows that they are unnecessary, I am doubtful in my own mind whether they are necessary or not. I am so doubtful, in fact, that in the beds that I am just building, as completing my scheme, I am putting shield tiles under the joints, not to protect the silica, but by reason of the jointing material—and the trouble with segmental silica in horizontal retorts is one of jointing material. Where the retorts project to the centre of the combustion chamber, the projecting part, and particularly the bottom joint of the corner segment of the retorts on the inner side, is exposed to the cutting effect of flame from the combustion chamber. The silica will undoubtedly stand, but, as you all know, in the jointing material we cannot use identically the same material or the same matrix that is employed in the manufacture of the bricks, because it is too coarse and will not stick. Even if we used the same material, it is doubtful if it would hold into the joints. Where the same material has been used, I believe there have been instances of its falling out. We therefore employ ground ganister very often, or silica sand mixed with fireclay or lime, perhaps from 10 to 14 p.ct. of fireclay or lime. A slight variation in the percentage of fireclay or lime is going to affect considerably the refractoriness of that jointing material; and if we get the jointing material on the corner joint exposed to the cutting flame from the combustion chamber, with the action of the flue dust in the gas, there is a risk of fluxing. If, on the other hand, we use the coarse material, and the jointing material falls out, there is also the risk of fluxing, the possibility of ash coming through from the retort, and possibly some iron, which may lower the refractoriness at that point. Those of us who have had even slight experience of silica realize that, once fusing sets in, it grows rapidly, much more so than in fireclay or semi-siliceous material. In conclusion on this point, I do think there is a case for a shield tile on segmental retorts, at any rate beneath the bottom joints, where

they may be exposed to the action of a cutting flame, or where there may be a possibility of the jointing material falling out.

Another point in the paper to which I will refer is the design of the regenerators, which gives an excellent result. The coke utilized on the producers is 1·48 cwt. per ton of coal carbonized. That is, I think, the best figure I have heard for any form of carbonizing up to date. On the installation at Stretford, for twelve months' working, the coke available for sale was slightly higher than at Brighton, amounting to 12·21 cwt. So far as we can ascertain, the actual coke used on the producers is equivalent to 1·95 cwt. per ton of coal carbonized, which I thought was a good figure. However, Mr. Rutter has done much better at Brighton. There is always a slight difficulty in ascertaining the figure accurately, and I should like to ask Mr. Rutter how the 1·48 was arrived at. I arrived at the figure of 1·95 for the Stretford results by constant tests of the coal in use throughout the whole year, to obtain a figure of yield of coke in a test plant working as nearly as possible under the same temperature conditions as the retorts. That is how the gross yield of coke, which at Stretford amounts to 14·16 cwt., was obtained, which, after taking the coke sold, leaves 1·95 cwt. per ton of coal carbonized as used on the producers.

There is one other point which I think is of great interest. Mr. Rutter has mentioned the question of waste-heat boilers in connection with horizontal retort working; and I thought it might be of interest if I gave the figures of a 14 days' steaming test on a waste-heat boiler working on settings of ten, similar to the Brighton setting, so far as capacity is concerned, except that they are 22 ft. long instead of 23 ft. The total water converted to steam was accurately measured both in tanks and by meters for checking purposes; and the average steam pressure over the whole period was 103 lbs. per sq. in., with from 85° to 100° of superheat. The steam raised was 6340 lbs. per hour, equivalent to 634 gallons of water evaporated with eleven beds of ten in operation. This is equivalent to—on coke used on the producers, which works out, on the eleven beds, at 1·3 cwt. per hour—practically 4 lbs. of steam per lb. of coke utilized on the producers; the coke used on the producers being, as I have already said, 1·95 cwt. per ton of coal carbonized. I think this justifies Mr. Rutter's claim that there is plenty of scope for—even with reasonably efficient working—sufficient waste heat fully to justify its utilization in boilers in connection with horizontal settings. In conclusion, there is one question I should like to ask Mr. Rutter as a point of interest, and that is the average weight of charge he is able to put in, in normal working, with the central chain machine which he uses at Brighton. I will also congratulate Mr. Rutter on giving us something which is new—the table of costs which he has added as an appendix to his paper. It is an extraordinarily valuable adjunct, and it adds to the value of this paper from a practical point of view. It enables us to make comparisons on reinforced concrete construction; and I am sure it will be of the greatest assistance to us all.

Mr. C. DRU DRURY (Member of Council, of Sunderland): I should like to join with Mr. Carr in expressing thanks to Mr. Rutter for his most interesting paper. The question of the remodelling and reconstruction of works comes to us all sooner or later, and, therefore, is of vital interest to us. Of course, we expect, and we ought to have, papers on the rather abstruse chemical reactions with regard to the various processes that go on in our works; and I think the President has rightly put these in the earlier part of the programme. For an after-lunch meeting, I think this present paper is most adaptable and very refreshing; and it is certainly much easier to listen to now than would be a more abstruse paper of the nature I have indicated. Mr. Rutter's paper deals largely with the retort house and carbonizing plant; and the few remarks I shall make will apply to that particular aspect of the paper. It is new to me, though it may not be new to others, to see stage floors constructed entirely of reinforced concrete; and I must say it commends itself to me. I take it that the stage floors are entirely independent of the retort house walls and the retort bench. If so, there is everything to be gained by that construction. Certainly the amount of corrosion on any stage floors constructed more or less in steel is a revelation to many of us when we come to overhaul that part of the plant. With regard to the question of silica and fireclay, I can bear out what Mr. Carr has said; and though I have not had a long experience, there is no doubt in my mind that the thermal conductivity of silica is much in advance of that of fireclay at the temperatures at which we carbonize coal. As a matter of fact, I can, with practically no increase of temperature in the combustion chamber, burn-off a 12-hour charge in 9 hours, or an 8-hour charge in 6 hours.

The PRESIDENT: What weight of charge?

Mr. DRURY: A charge suitable for the retort, whatever it may be—*i.e.*, the same charge in the retort in the two cases. On the other hand, I have no doubt, if my retort would hold it, that I could burn-off a much heavier charge in the same time as the lighter charge. With regard to the life of silica, this has yet to be ascertained, but from the observations I have made it seems to me that it will be distinctly longer than that of fireclay. The strength of the material is extraordinary, and one can throw segmental sections of retorts about on the ground in an endeavour to break them, and yet not even chip them. In the case of makers with whom I have dealt, the formation of these retort segments leaves nothing to be desired, and there is no chipping whatever in connection with them. With regard to the producers, I think there is everything to be gained by the use of the deep producers which Mr. Rutter has, and probably also in the distance he sets them out from the retort bench. Certainly his fuel results are extraordinarily good. As to fuel results, it is first necessary to ascertain how much coke is made for sale. It is difficult to get the exact fuel account, but you can ascertain how much coke you make per ton of coal; and if you know this, you know where you are. The 11½ cwt. seems an extraordinarily good figure. I wonder if Mr. Rutter means that this is wholly coke, free from breeze. Another matter of interest to us is the independent offtakes from the hydraulic mains to the tar towers. The paper has given me a wrinkle which will probably overcome some trouble, because it tells us how we can have a deeper seal at one end of the hydraulic mains than the other when they get a little bit out of level. With regard to the coke quenching bench, I have no experience of this; but I should like to ask the author whether he experiences any nuisance or trouble, under certain atmospheric conditions, from the steam from the quenched coke blowing into the retort house. I have been in retort houses where it has been extremely unpleasant when that condition of affairs obtained. I consider the author's schedule of costs extremely valuable. It will be referred to by many of us when we have work of this class to do. My only disappointment is that the author gives us no carbonizing results. Probably he did not intend to do so, as this paper is on construction. I think, however, that it would have indicated what his reconstruction work has cost, if he had given us some results.

Mr. G. M. GILL (London): There are, I am sure, many in the room who will agree with me that Mr. Rutter has given us a splendid description of a fine retort house; and it would seem that he and his assistants have made an excellent job of their reconstruction work. In the paper, he refers to his combustion chamber temperatures as being from 1350° to 1450° C. Of course, those are high temperatures, but I understand that in one retort house he has moulded fireclay retorts, supported by silica walls. I have often wondered whether, with that combination of moulded fireclay with a high percentage of silica (74 p.ct.) supported by silica walls, you could use really high temperatures; and I should be obliged if Mr. Rutter would let us know how long these settings have been working, because it would be excellent if we could use moulded fireclay retorts with silica walls, thus saving a lot of trouble in construction. Of course, dealing with this point, one must remember that, while the outside of the retort walls has to withstand these high temperatures, the inside part of the walls has a temperature perhaps 200° C. lower; and this enables a retort to withstand the higher temperature. Mr. Rutter refers to his producer gas, and states that before coking up it amounts to 19·4 p.ct. of carbon monoxide. I have always found that it is better to coke up more often, and to make and maintain a rather better quality of producer gas. In my working I used to try to keep, and was successful in keeping, an average of about 25 p.ct. of carbon monoxide. It is important to make a good quality of producer gas, because I think modern carbonization shows us that the thermal yield per retort per 24 hours is even more important than the thermal yield of gas per ton of coal. I believe that a high make per retort has a bigger bearing upon a cheap gas production than a high make per ton. A good quality of producer gas enables you to keep your retorts heated-up sufficiently to carbonize the quantity of coal that is necessary to give you that make per retort. With previous speakers, I wish that Mr. Rutter could give us the make per ton, the make per retort, possibly the number of men necessary to operate his retort houses, and the labour costs, the sizes of charges, and their duration. There is just one small point of criticism which I have to make, and that is in regard to fuel consumption. I notice that Mr. Rutter estimates his make of coke at 13·5 cwt., and that he sells 11·5 cwt. He uses 0·5 cwt. on his boilers, leaving 1·5 cwt.—I am speaking in round figures—as used in the retort producers. I take it that in the coke sold—*i.e.*, the 11·5 cwt.—there is some water; and if you allow for a reasonable amount of moisture in the coke, it brings 7·4 lbs. of fuel up to something nearer double, or at any rate a much higher figure than that given. Again, is the 13·5 cwt. the actual make of coke, because this is a very difficult figure to ascertain? One could only estimate it, and run tests from time to time to find out what it is. Mr. Rutter uses Durham coal—seaborne coal, I believe—and it may be nearer 14 cwt., in which case the fuel would be higher still. This account of the retort house work is most interesting to all the members; and I congratulate Mr. Rutter upon his description, and upon the way in which it has been put forward.

Dr. A. PARKER (Fuel Department, University of Leeds): The point I have to raise in connection with this paper might appear to be at first sight rather a minor one. I will not pretend to go into the constructional details, but would like to refer to two points which have already been raised—namely, fuel consumption and the composition of the producer gas. I agree with Mr. Gill that it is a difficult matter to get a really accurate figure for fuel consumed in the producer, because an error, for example, of only 10 p.ct. in the estimate of the coke make per ton of coal would mean—on that 10 p.ct. fuel basis—a possible

error of about 100 p.ct. on the fuel used in the producer; and this makes it very difficult to get at a really accurate figure. I mention this point because the fuel consumption given appears to be somewhat low. With regard to the producer gas, I refer to this because, as the result of a large number of analyses of the producer gases on different occasions, we have come to the conclusion that, as a general sort of average—of course conditions vary—a good producer gas would contain about 5 p.ct. of carbon dioxide, 25 to 26 p.ct. of carbon monoxide, and about 10 p.ct. of hydrogen; the latter resulting from the supply of water or steam to the producer. I should be obliged if Mr. Rutter could tell us what system is adopted in the case of these producers, whether water or steam is supplied. In either case water vapour does travel through the fuel bed. In fact it is necessary, in order to prevent clinkering and overheating of the producer. I mention this point because, with 0·9 p.ct. of carbon dioxide, the 19·4 p.ct. of carbon monoxide appears to me to be low. With regard to the hydrogen at 79·7, I assume that is really hydrogen *plus* nitrogen. It is simply a case of adding carbon dioxide and carbon monoxide and deducting from 100. I mention this because this producer gas has a composition very different from that of anything I have made in the analyses carried out.

Mr. DAVID VASS (Perth): Has Mr. Rutter been successful in getting a good commercial coke out of his breeze? I understand he washes his breeze in a "Columbus" washer.

Mr. J. W. BUCKLEY (Hornsey, London): The first thing that occurs to me in reading this paper is the remarkably good retort house that it was the luck of Mr. Rutter to have before him when he was considering his extensions; and when one thinks that as far back as 56 years ago a retort house of such capacity was built, it speaks volumes for the foresight and ability of the late Engineer to the Company, the late Mr. J. B. Paddon. In addition to this, he mentions the rotary washers, and he tells us that they have been working for the same period of 56 years. This also speaks very well for the ability of the late Mr. Paddon. I have no doubt that the size of the retort house guided Mr. Rutter in deciding to construct horizontal retorts. In passing, I should like to emphasize my remarks by saying that I remember reading about it, no less than 40 years ago, in King's "Treatise"—the work Mr. Rutter has described was also described in those books—and I remarked then that it was one to be considerably admired, even if not emulated. I believe that Mr. Paddon was ably assisted by Mr. Joseph Cash—I am sure Mr. Rutter will pardon my mentioning this—who became the Chief Engineer after Mr. Paddon resigned, and who, I believe, conducted the works with credit to himself and with satisfaction to the Board of Directors. I am much interested in the three types of producers which Mr. Rutter is working; and it would be interesting to know which of those producers he has found to be the best, considering cost of upkeep, because I think one is rather more costly in upkeep. With regard to the use of reinforced concrete for his coal bunkers and the chute coming out of the retort house, I should like to know really what guided Mr. Rutter in deciding on this rather than a metallic substance or brickwork. I was wondering whether the life of a chute from the retort house might be short; but no doubt Mr. Rutter will reply to this, and will give us his knowledge as to its suitability for the work for which he has provided it. I think also that it is much to the advantage of the gas industry that he has read this paper to-day, because I am sure—and I am speaking rather on the veteran side—that if the gas industry of the future is to keep its flag flying, there are three very important things to have in mind—namely, low capital expenditure, economy with efficiency, and low-priced gas.

Mr. W. W. ATLEY (District Member of Council, Stockton-on-Tees): While thanking Mr. Rutter for his very valuable paper, I should like to refer to his extensive use of band conveyors. While I can appreciate his point in using band conveyors, and agree that they are the cheapest form and require less power to drive them, yet in a case where the conveyor is inside the retort house, over the coal stores, I should like to ask him if he has considered the question of a drag-link conveyor. I have found that the latter, in the retort house, while requiring more power to drive it than a band conveyor, is a better proposition in the long run, because you do not require any extra labour to move along the draw-off carriage.

The PRESIDENT: There are one or two points I should like to ask Mr. Rutter, though, of course, I have the benefit of knowing his works fairly intimately. Everyone has been impressed by the figure of fuel consumption. Candidly, I should not have believed it, except that it was put forward by Mr. Rutter, whose work I know so well, and whom I know to be extraordinarily accurate in anything he does; but it would be interesting to hear what is his explanation of that. I believe I am right in saying that no such figure for horizontal working has ever been put forward, and if it is true it shows all of us what we have to emulate. When it comes to the question of deciding the factors on which this is based, however, it is very difficult. In my father's time at Hastings, he satisfied himself that the production of coke from Durham coal such as we were in the habit of receiving was 12·5 cwt. per ton of coal carbonized. I expect most of you will at once say that this is a very low figure; but for years it was accepted for our statistical purposes. More recently I have had occasion, with my assistants, to question the figure; but we have not been able to get the high figures which sometimes are brought forward as representing the coke produced in ordinary working per ton of coal carbonized. I believe the 12·5 cwt. is low; but, on the other hand, some of the figures which have been mentioned are high. I am sure it would be interesting for us to know what Mr. Rutter has to say in this connection. I want to ask him if he is satisfied with the quenching of his coke on the bench. I am interested in this, and should be glad to know if he has tested the percentage of moisture. No doubt he will also give us figures as to the wear and tear of the inclined bench. The question of moisture is a very important matter. I am, of course, gratified that Mr. Rutter has given these figures of cost, although, with his natural diffidence and hesitation, he was loath to do so. I did feel that they would be of great use to us here; and as they have been appreciated, I am obliged to him for having ceded to my request on your behalf. In his reply to the discussion, he might also deal with the question of expansion. At first I thought it was an error to allow for expansion of $\frac{3}{8}$ in. to 1 ft., and if he will enlarge upon that point it might be an advantage. Another moral which I think the paper points out is that those of us who are in a very small way, and who do not construct retort houses as a habit, but only build settings occasionally, should move slowly with silica material in retort settings. I have been exploring that; and I have had a little trouble in regard to this question of jointing, which has been so well put by Mr. Carr. I think there is a great deal in that; and it is a matter which we want to consider carefully.

Mr. RUTTER: The paper has been received most kindly; and I thank you all very much for the appreciation you have expressed. I can only add that it has been my pleasure for several months to concentrate on the preparation of this paper; and it is very gratifying to find that it is acceptable to the members. Mr. Carr raised the question of the silica, and the danger of the jointing material being run out of the joints by the heats; and he advocated having silica shields at the corner of the retort. I quite agree with him there. He also referred to the question of iron. I thought very likely that question might be raised; and I confess that I am perturbed at the behaviour of silica if there is any iron to come into contact with it. We have found from experiments—and we have made a great many experiments at Portslade with iron and silica in an experimental furnace—that the slightest trace of iron has a highly detrimental effect on the silica. It fuses it almost instantaneously; and if by any chance a nut or bolt gets into the retort with the coal, and comes into contact with the hottest part of the retort, it causes damage which is very costly to repair. It would be helpful if members who have had experience of that in connection with silica retorts would give information on it. With regard to the fuel account, Mr. Carr raised the question of the amount of coke produced per ton of coal, as did several other speakers. We have found, from many experiments, that from 13 to 13·5 cwt. per ton is the average production from Durham coal; and it is on this figure that the amount of fuel is calculated. I think it was Mr. Dru Drury who said that the best figure to take is the amount of coke sold out of the retort house. That is a definite figure, which one can always ascertain; and when it is anything like 11 cwt. or upwards, I think it must be considered a good figure. I was interested to note the figures which Mr. Carr gave as to the production from the waste-heat boiler. They will be useful to me by-and-by, when we get our waste-heat boilers in full working. With regard to Mr. Drury's remarks on the reinforced concrete construction on the stage floor, I do not claim any originality in that respect. I think the Croydon Gas Company were the first to use reinforced concrete for floor construction. We have used it entirely for both retort houses we have reconstructed. In the first instance, I admit, the beams were not made strong enough; and after several years of working they showed signs, not exactly of collapse, but certainly of weakness. In the second house we provided against this by making the beams deep. When you have modern retort house machinery weighing 30 or 40 tons—large charging machines with settings of ten—the amount of vibration when this is moving about the floor and jockeying into position for discharging the retorts is very great. The strain on the beams of the floor is greater, I think, than is generally supposed. Thus, if any members propose to use this particular construction, I should certainly advise them to have substantial beams under the rails supporting the charging machine.

I cannot give any information as to the life of silica, because we have not had any of it in use long enough. I suppose Mr. Hardie is in a better position to give information with regard to this than anybody else, as they use silica so much at Beckton, and have had much experience. Mr. Drury asked whether the steam from the coke bench was found to blow back into the house. At Portslade it does with a northerly wind; but our prevailing winds there are south-west, so that we do not notice it, and it is only on very few occasions that we are inconvenienced by the steam blowing back into the house from the sloping quenching bench. Mr. Gill's remarks, as usual, were of a highly technical character, which it is very difficult to answer without proper preparation. With regard to the 19 p.ct. of carbon monoxide, perhaps it is rather a low figure. All I can say is that we shall have to try to do better. In the paper, I mention that this figure was taken just before

coking, so that it is in the worst state of the fire. Mr. Gill also remarked on the fuel used; and I think I have answered his point in replying to Mr. Carr. Dr. Parker, in addition to mentioning the question of fuel, which I have already answered, asked whether we use water or steam in the producer. We use water, just for cooling the bars, and no doubt the evaporation of that water helps the fire. In reply to Mr. Vass, the washed breeze is used almost entirely in the works, but we sell a little of it, especially recently, when people will take anything that will burn. As a rule, however, we use it exclusively under our boilers.

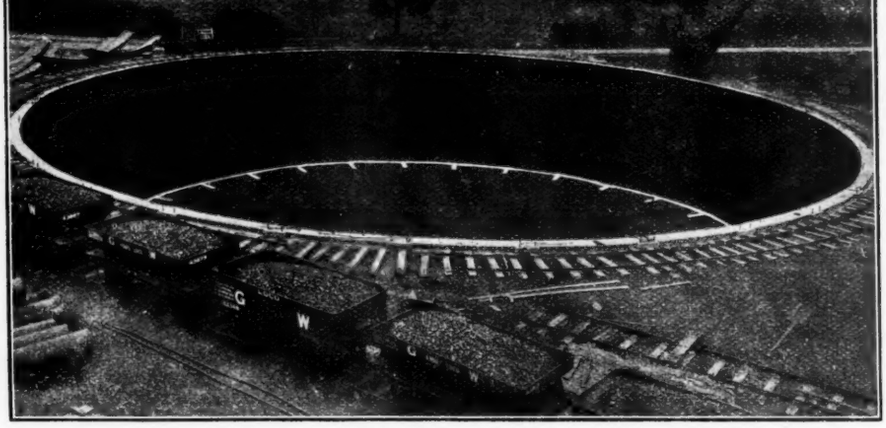
Mr. Buckley made some kind remarks, and I greatly appreciated what he said with regard to the work of the late Mr. J. B. Paddon, the original Engineer of the Portslade Works, and his successor, Mr. Cash, my dear old Chief, who is now one of my Directors, as many of you know. With regard to the three classes of producer, I suppose I ought not to say it, but I think the "Brighton" producer is the best—the deep producer. The coke bench is made of reinforced concrete covered with firebricks; and in reply to Mr. Buckley and another speaker who raised the question of the wear and tear, I might say that there is considerable wear and tear on that coke quenching bench, particularly in view of the fact that with the quenching of the coke the sulphurous fumes arise and attack the brickwork, as well as the brickwork piers round the house, and so on. We have, however, overcome that to a great extent by lining the piers with cast-iron plates. Mr. Atley raised the question of a drag-link conveyor instead of a belt conveyor for use in the retort house. I might say, with regard to the belt conveyor, that though it is situated right in the roof of the house, in the hottest part, where all the hot fumes come up, we do not find that it has been affected in the least by that fact. It has dealt with about 700,000 tons up to now, and will probably deal with 800,000 tons before it is entirely finished. The price of the belt conveyor nowadays is about half what it was when this was put in. I think it was, roughly, £1 per ft. when it was installed, but the price now is about 9s. 6d. per ft. It is a 64-ply belt, 24 in. wide. The President and one or two other speakers asked about the make per ton, and so on, and I am glad to be able to afford that information from a table which I have here. The average weight of the 8-hour charge we put in now is 10·38 cwt., and our make per ton is 13,500 c.ft. With Durham coal the therms are just over 70; but with some American coal we have been using recently, the therms have risen to 74 per ton. The cost of stoking in the old days, 6-hour charges, was 2·54d. per 1000 c.ft. made. Now, with 8-hour charges, it is 0·98d. per 1000 c.ft.; and whereas in the old days we had 60 men in a shift, and had two 12-hour shifts, making 120 men per day, we have now three shifts of 12 men per day, making a total of 36 men, for dealing with a quantity of coal half as much again as previously. The production is also half as much again, and the make per ton has gone up from 11,467 c.ft. to 13,512 c.ft.—an increase of just over 2000 c.ft. per ton. Then I have another figure here which may be of interest—it was not touched on by the speakers, but I may as well give it. By the old method of unloading coal, using steam cranes and hand-pushed trucks, it cost 1s. 6¼d. per ton, and the present cost is from 5d. to 5½d. per ton. Taking into account the cost of electricity, maintenance, and so on, it comes to 7½d. per ton, which is considerably less than half what it was, although, of course, wages have gone up by about 70 p.ct.

I think I have answered to the best of my ability all the questions that were raised; but if there are any other questions, and the President will permit it, I shall be very happy to answer them if they are sent to me in writing.

The PRESIDENT: This concludes the day's proceedings. Mr. Rutter requires no further thanks than the excellent discussion.

FERRO-CONCRETE IN GASWORKS

BREAKER PITS
PILING
TELPHER TRESTLES
TANKS



FOUNDATIONS
PURIFIER HOUSES
BUNKERS
CRANE GANTRIES

Ferro-Concrete Tank for 2½ Million Holder

F.C. CONSTRUCTION CO. LTD.
26, IRONGATE
DERBY

Telegrams: Reinforce, Derby

Telephone: Derby 1112

INVESTIGATION OF SOME OF THE FACTORS AFFECTING CARBONIZATION IN CONTINUOUS VERTICAL RETORTS.

By T. F. E. RHEAD, M.Sc., A.I.C., Chief Chemist, Birmingham Gas Department.

SECTION I.

PLANT EQUIPMENT AND CONTROL.

Introduction.

The Coal Test Works was erected in 1905 for the testing of coals and of various processes and plants for carbonization and gas purification. It has proved a valuable adjunct to the Department; and from time to time the Manager and the Gas Committee have granted permission for the publication of various investigations before this national assembly and other institutions—notably by Dr. W. B. Davidson, Dr. E. W. Smith, and Mr. G. C. Pearson.

In brief, the Coal Test Works is a completely equipped gas-works, with special facilities for making accurate observations and measurements, in connection with the carrying out of tests on coals, plants, and processes.

Since 1905 several types of plant have been erected and dismantled when they became obsolete. At present, the carbonizing plant consists of a bench of four beds of modern horizontal through retorts—each bed containing six Ω-shaped retorts 20 ft. long, 23 in. by 16 in ; capacity 36 tons per day, and a setting of Woodall-Duckham continuous verticals—four silica retorts, capacity 20-24 tons per day.

It is the practice to keep the carbonizing installation always at work, which gives an annual production of approximately 250 million c.ft. By working on this manufacturing scale, the results are representative of actual works practice, and are obtained at very little extra cost to the Department. When testing is in progress, there are the necessary valves, by-passes, and connections for isolating either installation or portions thereof, and sending the gas through the Test Works condensers, exhauster, scrubbers, purifiers, and works meter, after which it passes to the holders on the large works. The gas from the plant not under test is sent *via* booster and rotary meter into the main stream of crude gas of the adjacent large works.

The plant is run by a staff consisting of Superintendent, Staff Foreman, Shift Chemists, Shift Foremen, and workmen, the majority of whom are thoroughly experienced in gas-works practice, and have the skill born of many years' experience and training in making the careful observations and measurements essential for obtaining reliable test data. Well equipped laboratories run alongside the works, and every care is taken to use the best technical methods in connection with such important matters as sampling, pyrometry, gas testing, general chemical analysis, &c.

Continuous Vertical Installation.

Eighteen months ago we decided to reconstruct our continuous vertical plant. Fig. 1 shows this plant in diagrammatic form, together with the Coal Test Works scrubbing and purification system.

The retorts are 25 ft. long, and have a cross section 66 in. by 19 in. at the bottom and for 11 ft. up. They then start to taper somewhat gradually on the minor axis for a few feet, and afterwards more rapidly to a cross section of 60 in. by 8½ in. at the top.

The retort walls consist of fireclay tiles top and bottom, with a 17 ft. belt of 3 in. silica tiles in the heated zone; and each retort, together with its eight combustion chambers, is built on the monolith principle. The whole of the secondary air is supplied to the top of each combustion chamber 3 ft. down; but there are two ports for producer gas, one 4 ft. down, and one 8 ft. down.

Fluctuations in Carbonizing Results—Need for Investigation Using a Single Retort.

A number of tests carried out with various coals, and methods of heat zoning, while giving useful commercial results, pointed to the need of a closer examination of the effect of various disturbing factors on continuous carbonization. It was therefore decided to isolate one retort, and pursue such investigations when more urgently required testing work was not in progress. The smaller quantity of coal carbonized by one retort brought into prominence the relationship between experimental error and duration of a test period. In order to reduce experimental error, and improve the control of the plant so that a test period could be limited to four days (first day for tuning-up), special care was devoted to the important matters discussed in the following pages forming Section I. of this paper.

Governing.

The ordinary form of retort house governor did not keep the "pull" within the limits required; and a trial was given of a new type of "relay" governor recommended by Messrs. Woodall Duckham & Co.—viz., the "Askania" governor. Fig. 2 represents the equipment in diagrammatic form, and fig. 3 shows a photograph of the set in use.

The relay mechanism consists of a pivoted jet delivering a stream of oil (pumped at 60-70 lbs. pressure) into either or both of the orifices of two pipes separated by a division plate about 1 mm. thick. These pipes are connected to opposite ends of a horizontal cylinder full of oil, in which a piston works. The piston is attached, by rod and levers, to a 10-in. butterfly valve (in the foul main above the retort), which controls the flow of gas from the retort.

The pivoted jet, of light construction, is attached, by means of a rod, to a vertical diaphragm open to the atmosphere on one side, and subject to the pressure of the gas in the top of the retort on the other side. Alteration in gas pressure causes movement of the diaphragm, and this in turn moves the jet. This causes the high-pressure oil stream to be delivered to the orifice of one pipe more than another, which results in a corresponding movement in the piston and butterfly valve. This allows more or less gas to be drawn from the retort by the exhauster (a pull of 1½ in. being maintained between the exhauster and the butterfly valve), and adjusts the retort pressure. The oil is continuously flowing back to a reservoir, from which it is delivered to the jet by a motor-driven rotary pump.

This instrument governed the pressure within the limit of $\frac{1}{40}$ in. water gauge, even with a large percentage of fluctuations in gas volume. Fig. 4 is a photograph of an actual record, where each division equals $\frac{1}{20}$ in. water gauge. The alteration in pressure was intentional, and indicates the nicety of control possible. The fluctuations from a single retort are more rapid than the resultant fluctuations from a bench of several retorts, hence the above governing is very satisfactory.

Perhaps it is worth pointing out that, when a governor is fixed on the foul main from a bench of retorts, although it may be maintaining constant pressure on inlet governor, the "pull" on an individual retort may vary, due to fluctuations in make from that retort. This will happen unless the off-take pipe and foul main are large enough to accommodate extra gas without appreciable increase of frictional resistance (which would be tantamount to putting some back-pressure on the retort). The greater the refinement required in governing, the more important is this factor.

Most Suitable Pressure in Top of Retort.—It has been found best to adjust the governor to give "level gauge" conditions in the top of the retort. This approximately balances the pressures in the retort against those in the combustion flue, and reduces the chances of pulling-in furnace gases, or driving out retort gases.

Effect of Governing on Life of Retort.—If for any reason a retort joint starts to open, bad governing causes ebb and flow of coal and furnace gases, and the crack soon becomes a serious leak.

Effect of Governing on Duration between Scurfing Operations.—The length of time a retort will work without shutting-down for scurfing is considerably influenced by steady governing. We find it quite an easy matter to

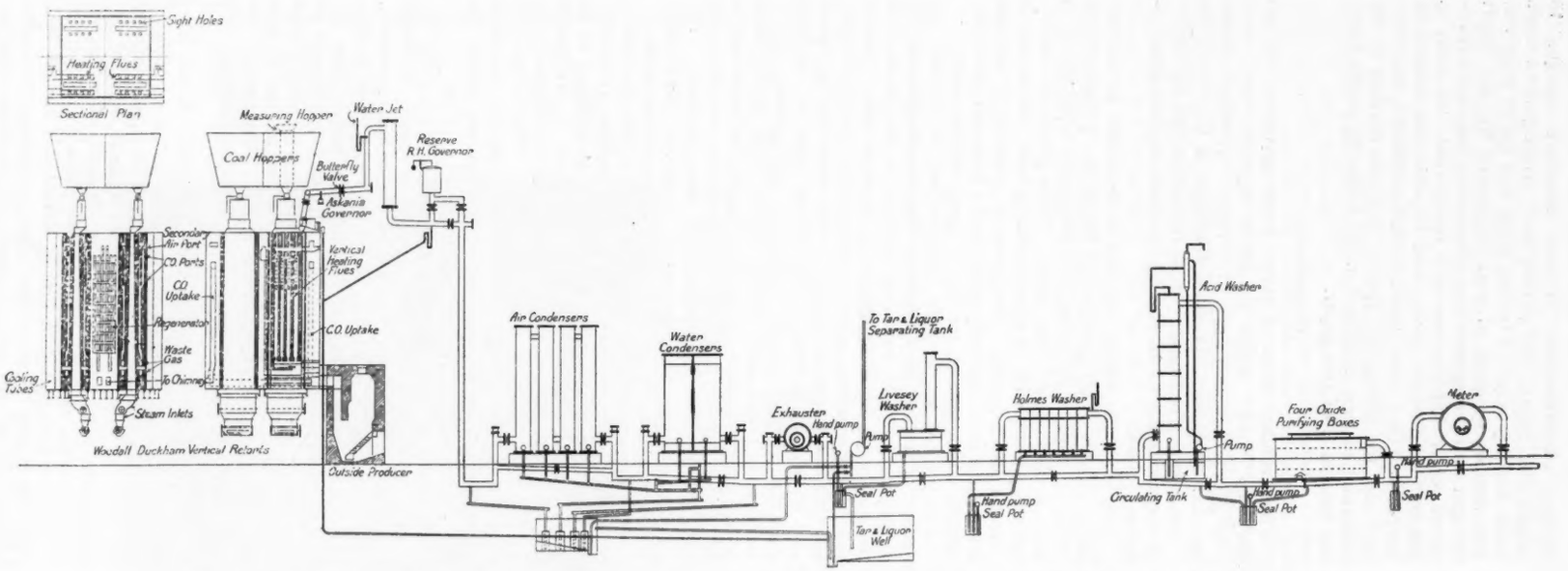


FIG. 1.—FLOW DIAGRAM OF WOODALL-DUCKHAM VERTICAL RETORTS, CONDENSERS, SCRUBBERS, &c., AT THE COAL TEST PLANT, CITY OF BIRMINGHAM GAS DEPARTMENT.

bring-off large sheets of scurf from a retort working very satisfactorily, by putting the retort under one-tenth to two-tenths pull; it then starts "hanging-up."

Another recent governor of a somewhat different "relay" principle, which gives good results (although we have not tried it on the Coal Test Works) is that embodying the "Arca" regulator. Many members may be using it.

Determination of Rate of Coal Throughput.

This is determined in the following manner: The coal, after crushing (so that approximately 90 p.ct. passes a 2-in. screen), is elevated to a storage hopper, and from there charged into bogies holding about 9 cwt. These are weighed on a carefully-checked 1-ton weighing machine, and taken by electric lift to the top of the bunkers above the retorts. Instead of being discharged into the large bunker, they are discharged into a narrow wooden chute extending upwards from the coal valve (of the retort auxiliary hopper) to the bogie platform. After each hourly filling of the auxiliary hopper, the wooden chute is filled just level with the top, and the coal bogie taken down and re-weighed; the difference in weights giving the amount used by the retort during the hour. This method of coal weighing, as shown by several check tests over a 24-hours' run, proves quite as accurate as the weighing of 10 or 12 ton wagon loads on a large machine. The coke is discharged hourly, and weighed in a similar manner. In order to eliminate any small variations in the intervals between each discharge of coke, the totals for each four hours are employed for comparative purposes.

Determination of Rate of Coke Extraction.

In order to eliminate any possible slip of the extractor with the usual wheel and friction driving pawl, a toothed wheel and pawl were fitted. The steam to the extractor engine is passed through a reducing valve, and the engine speed regularly taken with the speed indicator. A counter is also fitted to the reduction-gear shaft. The matter of extractor speed receives very careful attention.

Steam to Retorts—Generation and Measurement.

Water is fed from a constant head through a carefully-calibrated jet into the top of a long vertical 2-in. tube. It passes from this tube at the bottom by way of a non-return valve into a small vertical cross-tube boiler. The boiler is heated by Mond gas at constant pressure, and gives very uniform evaporation, once it is set to evaporate at the desired rate. The steam is passed through a very short service into the coke chamber of the retort, either through a nozzle which offers a resistance of 10-lb. pressure or through a $\frac{1}{2}$-in. open tube. By this means, the weight of steam used is determined by the water passing through the jet to the boiler; this is timed once per shift. Several periods of careful observation have shown that a very even delivery of steam can be obtained by this means.

Gas Metering.—The gas, after purification, is metered through a wet meter of 10,000 c.ft. per hour capacity. This meter receives frequent checking, and any error (which is always less than $\frac{1}{2}$ p.ct.) is corrected for.

Tar and Liquor Collection and Measurement.

When the Test Works was constructed in 1905, portions of the gas mains were buried in the ground, and large "syphons" employed as tar and liquor drains. These, of

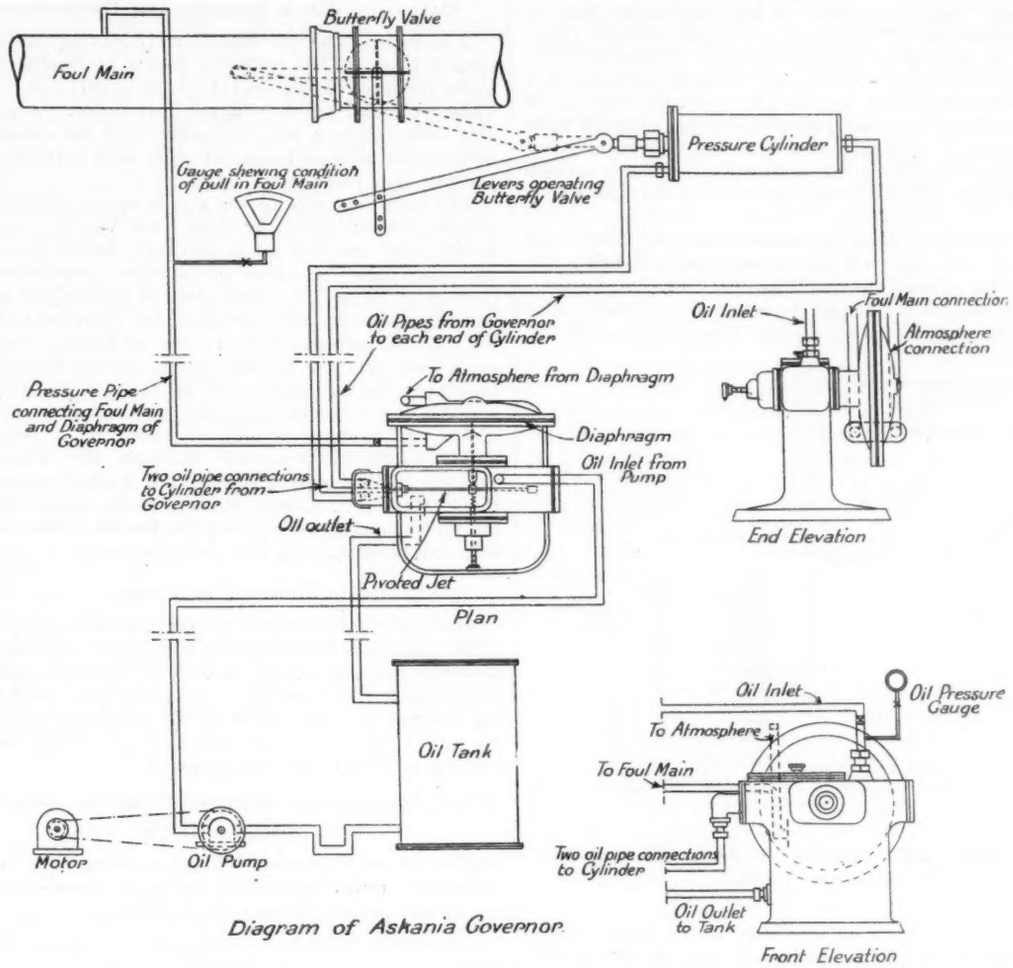


Diagram of Askania Governor.

FIG. 2.

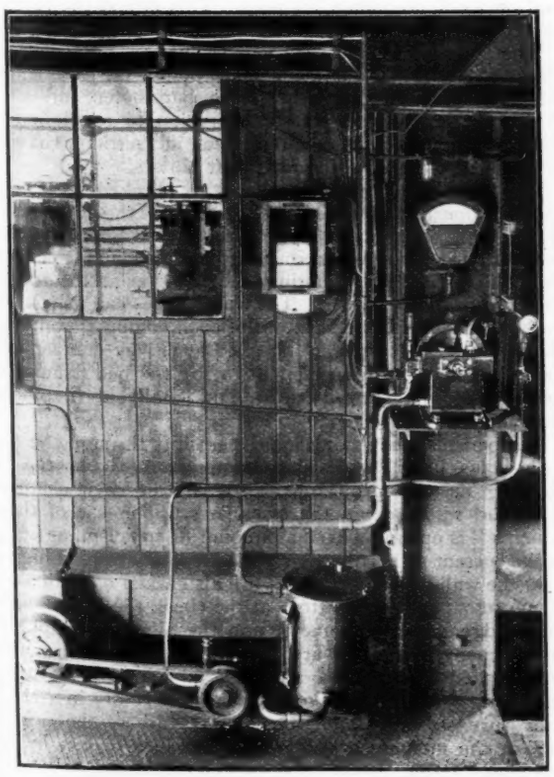


FIG. 3.—ASKANIA GOVERNOR EQUIPMENT. (LESS PISTON AND BUTTERFLY VALVE.

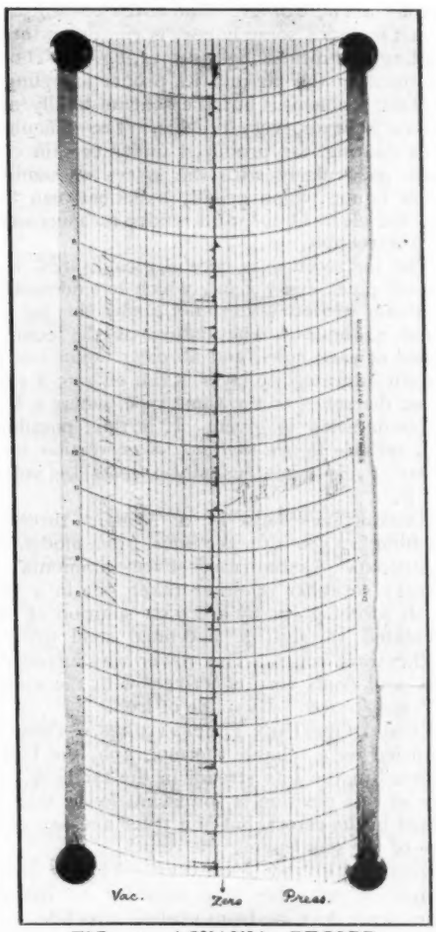


FIG. 4.—ASKANIA RECORD.
(ONE DIVISION ON CHART = 1/20 IN. WATER GAUGE.

course, held large quantities of tar, and made the tar determinations for a three-days' run from a single retort hopeless, in both quantity and quality. These syphons have been eliminated, and the tar allowed to drain to a central bosh—by which means all "pockets" of tar in the gas mains, condensing and scrubbing systems have been eliminated. Further, the air condensers are by-passed, as it is found that the foul mains are large enough to cool the gas sufficiently before it enters the water condensers.

The tar and liquor from the central bosh, scrubbers, and retort tar-pot are collected in a rectangular tank below the ground level, which has facilities for rapid inspection. From here they are pumped to covered overhead tanks with cone-shaped bottoms; the tar being trapped in the

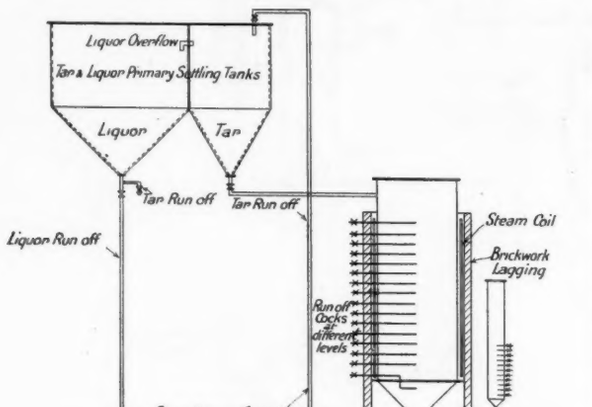


FIG. 5.—TAR AND LIQUOR SEPARATING AND MEASURING TANKS.

tar tank, and the liquor overflowing to the liquor tank. Any tar in this latter tank is carefully run off, and added to the main bulk of tar. The entire content of the tar tank, which includes some liquor, is run down into a special tar settling and measuring receiver, fig. 5. The correct ascertainment of the tar and its proper sampling have proved difficult problems; but the scheme finally adopted is, the author believes, very reliable. The difficulties have been with floating tar produced under certain conditions, but more particularly with the layers of semi-emulsion and black liquor which usually exist between the tar proper and the clean liquor, and render measurement by dipping very unreliable.

The tar receiver is carefully calibrated, and fitted with run-off pipes every 3 in., which extend to the centre. It is steam heated (externally), and the tar is allowed to stand 24 hours. The nature of the contents is determined at each coks, and all clear liquor run off. The uncertain intermediate layer is run off into a smaller receiver 16 in. diameter, of the same type, where a further settling and separating is given. It is thus possible to obtain a very reliable figure for tar. A correction for temperature to 60° F. is made, usually 1 p.ct. by volume for each 30° F.

EXHAUSTER.—This is a Waller three-blade rotary machine, 12,500 c.ft. per hour, 1924 model, steam driven.

AMMONIA ABSORPTION.—Free ammonia passing the Livesey scrubber is either taken out in a Holmes rotary brush scrubber, or by a 2 p.ct. solution of sulphuric acid, circulated through a lead-lined steel tower, filled with earthenware rings. This tower was introduced five years ago, and deals very effectively with the ammonia.

PURIFICATION.—By oxide of iron.

RETORT OFF-TAKE TEMPERATURES.—These are regularly recorded by a reliable thermograph, the bulb of which is inserted in the gas stream in the tar box. The temperature at this position is somewhat lower than would be obtained in the retort, but is a truer average of the temperature of the gas leaving the retort.

RETORT BOTTOM PRESSURE.—This is recorded on an open-scale sensitive tape recorder on the aneroid principle, scale ± 1 in. from central zero line.

CALORIFIC VALUE RECORDS AND DETERMINATIONS.

A stream of the gas immediately leaving the retorts is passed through the modified Evans apparatus described under methods in Section III. of the paper, and its calorific value recorded on a "Sigma" recorder. A portion is also collected in a 10 c.ft. holder, and the calorific value determined once or twice per shift on a carefully-checked Junkers flow calorimeter outfit.

The calorific value of the gas is again recorded (Beasley) at the outlet of the Coal Test Works' 10,000 c.ft. meter, and sampled in a 200 c.ft. holder for analysis and for calorific value on another calorimeter outfit (Junker or Boys). It is not usual to do analyses and C.V. determinations on both samples; but these have been done for various periods, with a view to finding how far results from the two systems agree. From Section III. of the paper the agreement will be seen to be fairly good; and the object has been to test out a scheme whereby the crude gas from each unit or bench of a large retort house could be switched through the machine for calorific value determination. The author would like to thank Mr. E. V. Evans, F.I.C., of the South Metropolitan Gas Company, for giving the benefit of his experience with small exhausting and purifying sets.

CONTROL OF HEATS.

The retorts are heated by the combustion of hot producer gas from large outside step-grate producers. The producer gas can be fed to each of the eight combustion chambers at either or both of two ports 4 ft. and 8 ft. down the brickwork. The whole of the secondary air is fed to the top of the combustion chambers 3 ft. down, after preheating in waste heat recuperators.

TOP SINGLE-STAGE HEATING (HIGH TOP, MODERATE BOTTOM HEATS)

implies the use of the top CO ports giving 1400°-1450° C. about 7 ft. down brickwork, falling to 1000°-1100° C. at the check tiles 20 ft. down the brickwork.

TWO-STAGE HEATING (MODERATE TOP, HIGH BOTTOM HEATS)

implies using both top and lower CO ports, giving moderate heats of 1250°-1350° C. at 7 ft. to 13 ft. down, and gradually falling to 1150°-1250° C. at the check tiles.

Note.—Each combustion chamber has two CO ports, and only one secondary air port. This is just the reverse of what obtains on standard Woodall-Duckham settings.

The "pull" on the heating system is by means of chimney draught, and from some points of view leaves much to be desired. Changes in barometer and wind direction call for very careful attention to regulation of heats. The trouble is eliminated in settings having mechanical draught and waste heat boilers.

The flow of producer gas can be checked at (*a*) the top CO distributing flue on each side of the retort, and (*b*) at both ports into each vertical flue. Similarly, the secondary air can be controlled at (*c*) its inlet to recuperator, (*d*) at each distributing flue, and (*e*) at the top of each combustion chamber. The waste gases can be (1) partially checked at (*f*) the bottom of each combustion flue by check tiles, (2) completely checked at (*g*) by damper into the common waste gas flue, at (*h*) by the bed damper at the bottom of the recuperator, and finally at (*i*) by the chimney damper.

Temperatures are taken once per shift through the top sight-holes of all accessible combustion chambers, by sighting on two projecting "soaps" in each chamber 7 ft. and 13 ft. down the brickwork. The use of these "soaps" is open to a certain amount of criticism, as being in the current of burning gas they are likely to read higher than the walls. Temperatures are also taken on both sides of the retort near the bottom at the check tile levels. The Cambridge optical pyrometer and the Siemens disappearing filament pyrometer are used; and both instruments are checked frequently against a gold wire melting-point standard, by sighting on to a fireclay refractory in a black body furnace, and noting the temperature of the refractory at the moment a gold wire lying in a groove in the refractory fuses.

Temperatures are taken more frequently when making

alterations to dampers; and, in addition, waste gas analyses are freely used.

The carbonizing plant was designed as a commercial testing unit for coals, and as a guide on commercial lines to give the engineers some standard to work to on their larger plants. It was not built as a research unit, and therefore does not lend itself readily to the refinement of control desirable for research work, as any given proportioning of the several streams of producer gas and secondary air by balancing these against the chimney draught is very difficult. A slight alteration in the amount of throttling given to one stream is liable to react on the others. Such special refinement of control could only be obtained by the supply of fuel gas and air through control cocks. Another difficulty is that of determining the exact distribution of temperature in each combustion flue, as the view through the top sight-holes gives such a foreshortening effect to the retort wall.

Effect of Retort Processes on Temperature.

Temperatures are also liable to considerable alteration by the processes taking place inside the retort. Any conditions which interfere with the steady absorption of heat in the retort—such as a charge "hanging," gas "channelling," or coal alteration—will have an effect on the distribution of temperature in the combustion flue.

Temperature distribution is thus seen to be subject to variation from causes originating both inside and outside the retort. When carbonizing under normal conditions, and two-stage heating, it is not uncommon to find the highest temperature at different levels in the combustion chamber during the same day.

SECTION II.

TESTS AND EXPERIENCE; COMMENTS AND DEDUCTIONS.

Coals Used in Tests.

Most of the tests have been made with two typical screened gas coals, which will be designated "A" and "B."

"A" is a slightly swelling coal, which gives 70 therms of approximately 550 B.Th.U. gas, 12·8 gallons of dry tar, and 35 gallons of 10-oz. liquor in horizontals. "B" is a rich highly-swelling coal, which gives 76·8 therms of 550 B.Th.U. gas, 12·5 gallons of dry tar, and 27·5 gallons of 10-oz. liquor in horizontals, under the same conditions as for "A."

Fluctuations in Throughput and Retort Working.

When conducting a series of tests* on coal "A" (crushed so that approximately 90 p.ct. passes a 2-in. screen), with apparently steady conditions of temperature, steaming, pull, extractor speed, &c., we were impressed with the fluctuations in quality and quantity of gas, and the rate of throughput which took place during a three-days' test. The calorific value very frequently departed from that constancy associated with verticals, but usually obtained as an average effect from several retorts (in which case the effects of fluctuation of individual retorts often cancel one another).

The fluctuations seemed to be too great to be put down to imperfections in control, and caused the author to concentrate attention on rate of extraction.

With a constant extractor speed, &c., the following points might influence the rate of coke extraction:

(1) Variation in coke qualities, such as:
  (*a*) Property of fracturing.
  (*b*) Size of fractured pieces.
(2) Frictional retardation of descent of coke column in retort.
(3) Actual holding-up of charge by broken scurf riding on the extractor.

No. 3 can be dismissed, as the retort was not showing any signs of shedding scurf.

No. 2 is less easy to ascertain, as the charge might keep on the move, and yet vary in rate of descent. It scarcely seemed likely, however, with the low swelling type of coal in use, the coke from which would tend to leave the sides of the retort.

* A preliminary run of 24 hours is made before each test to obtain settled conditions.

The reason therefore for variation in rate of coke extraction is apparently contained in point No. 1.

Apart from carbonizing conditions, the factors likely to affect the coke are variation in chemical composition and physical condition of the coal (assuming, of course, a satisfactory feed to the retort). Coal "A," however, has proved one of our steadiest coals as regards quality; but, on the other hand, the physical condition of size of coal varies considerably, owing to segregation in bunkers, &c., resulting in the retort being fed with a charge of varying sizes from time to time.

Effect of Coal Size on Results (Coal "A").

Tests were therefore made on coal "A" (1) graded to pass through a 2¾ in. and over a 1¼ in. screen—*i.e.*, containing no smalls nor fines below 1¼ in.—and (2) on a further quantity of this sized coal after passing it through the usual coal breaker (90 p.ct. would then pass a 2 in. screen, and contain considerable fines). The results are given in Table I.

The extractor at the commencement of test No. 1 was set at a speed which normally gave an approximate throughput of 6 tons with ordinary crushed coal ("A"); but in spite of an intentional reduction in speed, during test the throughput rapidly increased, and averaged 8 tons. In Test No. 2, although the extractor was intentionally speeded-up, the throughput only averaged 6·4 tons. It will be seen that the graded coal makes a smaller coke than the crushed coal, and as a consequence the coke passes the extractor more readily. The differences in throughputs are too great to make comparisons of the therm production; but No. 1 gave 3 to 4 gallons more tar than No. 2. Considering the high throughput, the volatile matter in the coke is remarkably low (the retort was designed for 5-ton throughput). A higher percentage of steam might have given more water gas, though the temperatures at the bottom were already on the low side.

Table I.

Test No.	1.	2.	P Ct.
Duration of test	72 hours	72 hours	..
Coal	A	A	..
Coal Size	2¾ in. by 1¼ in.	Above 2 in.	7·4
" "	..	2 in. by 1¼ in.	27·6
" "	..	1¼ in. by ¾ in.	23·4
" "	..	Below ¾ in.	41·6
Coal analysis, p.ct.:			
H_2O	4·8	5·4	..
Ash	7·7	7·7	..
V.M.	35·3	36·1	..
Tons per day	7·99	6·43	..
Extractor engine speed	195 R.P.M.	210 R.P.M.	..
Lbs. steam delivered per hour	57·4	57·4	..
Percentage steam on coal	7·7	9·6	..
Zoning of heats	Single stage	top heats	..
*Temp. of combustion flues	1361° C. (Tops)	1409° C. (Tops)	..
*Temp. of combustion flues	999° C. (Bottoms)	967° C. (Bottoms)	..
Coke Size:			
Quantity graded	38 cwt.	20 cwt.	..
Above 2 in.	31·6 p.ct.	47·9 p.ct.	..
2 in. by ¾ in.	54·3 "	39·5 "	..
Below ¾ in.	14·1 "	12·6 "	..
Percentage V.M. in coke	2·9	2·3	..

*7 ft. and 20 ft. down the brickwork.

The tests since repeated with the throughput adjusted to nearer 6 tons per day confirm the first results, and are typically represented in Table II.

In changing-over to large graded coal from crushed coal, the extractor has to be reduced 20 to 30 p.ct. in speed. The off-take temperatures fall considerably, and this heat conservation is reflected to a certain extent in the temperature rise in the setting. There is better steam cracking, resulting in increased production of water gas, partly due to increase in temperature, and partly due to the larger surface contact with the steam, the latter passing up through the porous charge. There is a larger yield of gaseous therms, generally of a poorer quality, and a large increase in tar and liquor, due to increased internal heating and the products being enabled to leave the retort without passing up the heated retort walls. The liquor in test No. 4 is somewhat low—it usually gives about 30 gallons.

The effect on the size of the coke is seen from Table III.

TABLE II.

Test No.	Coal (A). 3.		Coal (A). 4.	
Duration, hours	71		122	
Coal Size	3 in. by 1¼ in.		90 p.ct. below 2 in.	
Extractor engine speed	145 r.p.m.		205 r.p.m.	
Throughput, tons per day	5·77		5·94	
Make per ton, c.ft.	17,844		16,056	
Calorific value, gross B.Th.U.	460		478	
Therms per ton	82·1		76·7	
Therms per retort per day	474		455	
Percentage steam	10·48		10·16	
Tar, gallons	17·0		13·0	
Liquor, 10 oz.	37·6		28·2	
Percentage dry coke	58·7		60·7	
Coal analysis, p.ct.:				
H_2O	5·8		6·1	
Ash	8·4		8·6	
V.M.	34·7		36·1	
	P.Ct.	Vols. per Ton.	P.Ct.	Vols. per Ton.
Gas analysis:				
CO_2	2·1	375 c.ft.	3·1	498 c.ft.
HC	1·2	214	1·7	273
O_2	0·3	54	0·2	32·1
CO	20·5	3657	17·2	2762
H_2	51·2	9171	52·7	8463
CH_4	17·8	3175	19·3	3100
N_2	6·9	1230	5·8	931
Heat zoning	Single-stage top heating.			
Temperatures* Top	1395° C.	..	1349° C.	
Temperatures* Bottom	1188° C.	..	1127° C.	
Average off-take temperatures	75° C.	..	115° C.	

* 7 ft. and 20 ft. down brickwork.

The coke from the large coal was made in test No. 3. That from the crushed coal was not made in test No. 4, but nevertheless under the same conditions, and is typical.

The charge of large coal worked much more smoothly; but the larger lumps occasionally held up on the inverted V deflecting plates in the Woodall-Duckham Standard Top Ironwork. This inverted would be quite unnecessary for cobble coal.

There were no fluctuations in bottom pressures such as occur with crushed coal. The steady bottom pressure (fig. 6), or rather "pull," equal to 2½-tenths, is evidence of the porous or open nature of the charge, and obviously is readily controllable with proper governing, which enables leakage to be reduced to a minimum. On the other hand, the fluctuating bottom pressure of the crushed coal charge indicates that leakage is much more likely to occur since the pressure in the combustion flues is steady at approximately *plus* ½-tenth at the top, and *minus* 2½-tenths at the bottom.

The off-take temperature and calorific value are much more steady, as shown in fig. 7. Similar records for crushed coal are shown in fig. 8. Owing to the cool off-take temperature, the rodding-hole plugs remain moist; the off-take pipe requires very little attention; and there is no pitchy deposit in the tar box. Fig. 9 shows in a striking manner the effect on off-take temperature of changing-over from large graded coal to crushed coal.

Effect of Coal Size on Coke from Coal "B."

It was decided to try the effect of coal size on a rich

Effect of Size of Coal on Size of Coke.

TABLE III.—*Coal "A," 10 P.Ct. Steaming. Single-Stage Top Heats.*

Size of Coal.	Temperature, °C. Tops.	Temperature, °C. Bottoms.	Quantity Coke Graded.	Grading. Above 4 in.	4 in. by 3 in.	3 in. by 2 in.	2 in. by 1½ in.	1½ in. by ¾ in.	¾ in. by 7/16 in.	Below 7/16 in.
3 in. by 1½ in.	1395	1188	1½ tons	..	1·6	18·2	33·3	30·7	7·0	9·3
90 p.ct. below 2 in.	1364	1207	2½ ,,	0·3	5·6	31·6	29·8	19·0	4·4	9·1

TABLE IV.—*Coal "B." Top Single-Stage Heating. 10 P.Ct. Steaming.*

Size of Coal.	Quantity Graded.	Temperatures, °C. Tops.	Temperatures, °C. Bottoms.	Above 5 in.	5 in. by 4 in.	4 in. by 3 in.	3 in. by 2 in.	2 in. by 1½ in.	1½ in. by ¾ in.	¾ in. by 7/16 in.	Below 7/16 in.
3 in. by 1½ in.	40 cwt.	1370	1117	0·1	1·3	7·7	30·5	32·4	16·4	4·0	7·5
90 p.ct. below 2 in., containing fines	25 cwt.	1362	1165	..	2·2	9·0	41·5	23·0	12·9	3·5	7·9

TABLE V.—*Effect of Temperature on Size of Coke from Coal "A."*

Amount Graded.	Temperature, °C. Tops.	Temperature, °C. Bottoms.	Temperature, °C. Average.	Coke Grading Percentages. Above 5 in.	5 in. by 4 in.	4 in. by 3 in.	3 in. by 2 in.	2 in. by 1½ in.	1½ in. by ¾ in.	¾ in. by 7/16 in.	Below 7/16 in.
57 cwt.	1398	1009	1203	..	2·3	10·5	36·2	25·0	14·4	5·8	7·4
50 cwt.	1364	1205	1284	..	0·3	5·6	31·6	29·8	19·0	4·4	9·1

TABLE VI.—*Effect of P.Ct. of Steam and Coal Size on Size of Coke. Coal "A."*

Test.	Cwt. Graded.	Percentage Steam.	Throughput.	Temperature, °C. Maximum.	Temperature, °C. Minimum.	Coke Grading Percentages. 5 in. by 4 in.	4 in. by 3 in.	3 in. by 2 in.	2 in. by 1½ in.	1½ in. by ¾ in.	¾ in. by 7/16 in.	Below 7/16 in.
Two-Stage Heating—Crushed Coal containing Fines.												
5	24	15	6·3	1243	1131	0·5	9·6	34·8	25·0	14·9	6·6	8·4
6	23	20	6 13	1250	1124	1·2	9 7	36·2	23·5	14 6	6·9	7·9
7	18	24·4	6·10	1254	1148	1·8	10 9	32·3	25·6	14·9	6·7	7·8
Single-Stage Top Heating.—Crushed Coal containing Fines.												
8	31	14	6·6	1404	995	3·4	9·9	35·9	26·9	14·0	5·6	7·0
9	24	19·7	6·2	1393	1024	1·2	11·2	36·6	23·2	14·8	6·0	7·9
Single-Stage Top Heating.—Grade Coal, 3 in. by 1½ in., without Fines.												
10	22	10·5	5 8	1393	1184	..	1·6	18·2	33·3	30·7	7·0	9·3
11	25	15·0	6·3	1387	1156	0·5	2·4	16·3	34·1	25·2	9·6	11·9

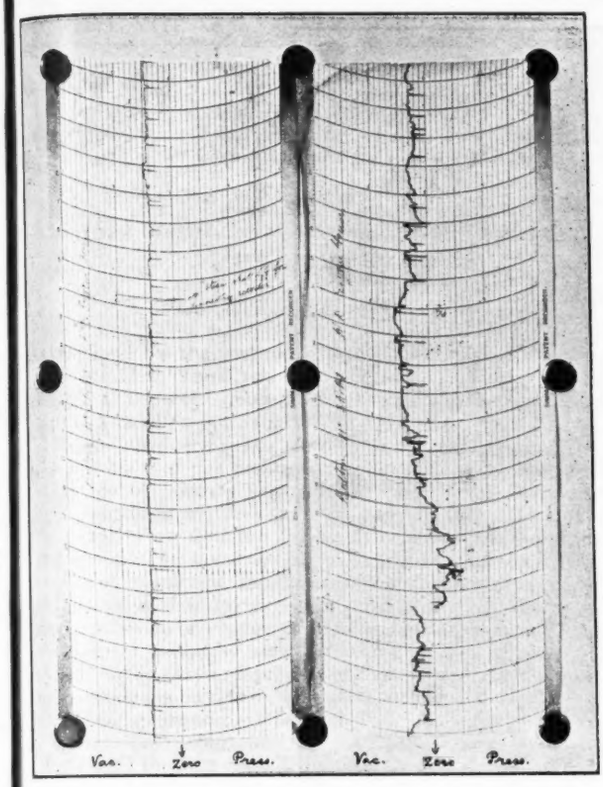


FIG. 6.—BOTTOM PRESSURES. POROUS AND NON-POROUS CHARGE. COAL A.

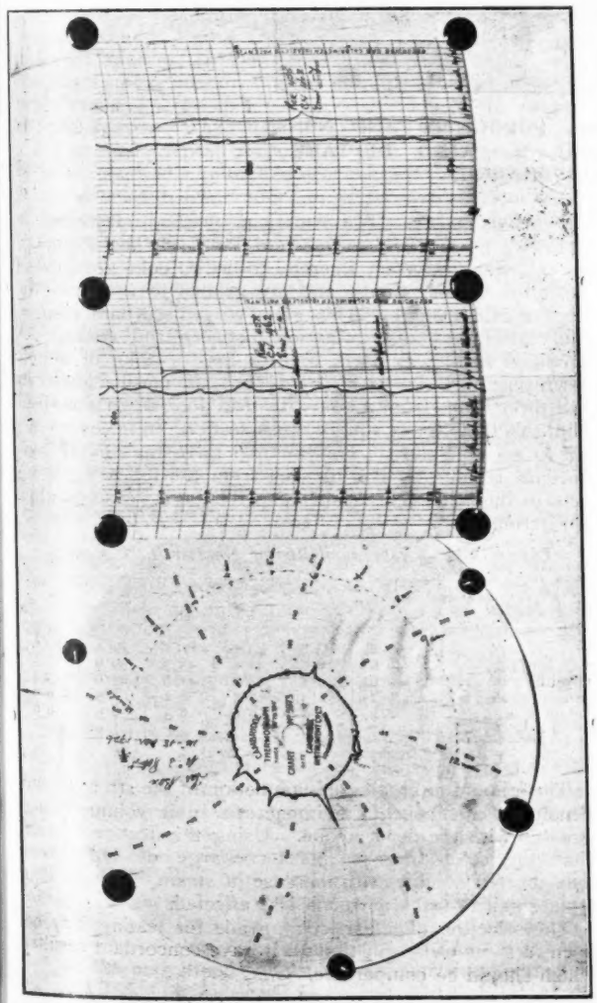


FIG. 7.—OFFTAKE TEMPS. AND C.V. RECORDS (COAL A. POROUS CHARGE). CALORIMETER 1 AT OFFTAKE. CALORIMETER 2 AT STATION METER. (TOP CHART).

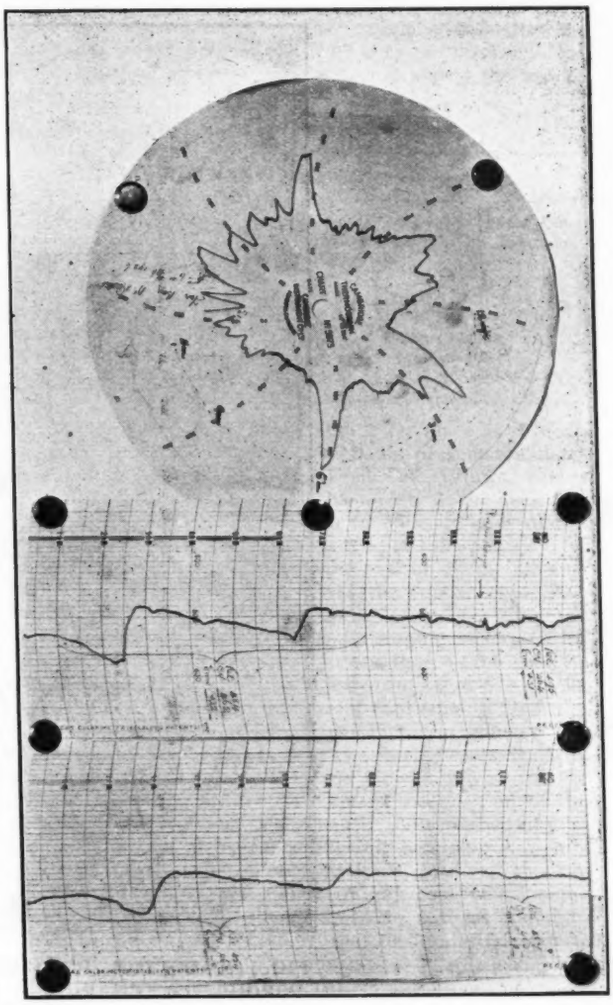


FIG. 8.—NON-POROUS CHARGE, COAL A. OFFTAKE TEMP. AND C.V. RECORDS AT OFFTAKE (1) AND STATION METER (2). (BOTTOM CHART).

(Note Relationship between C.V. and Temp.)

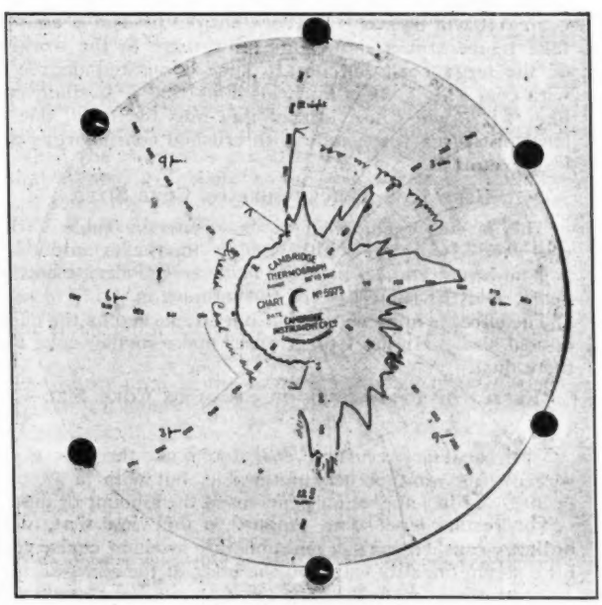


FIG. 9.—CHANGING FROM POROUS TO NON-POROUS CHARGE. EFFECT ON OFFTAKE TEMP. COAL A.

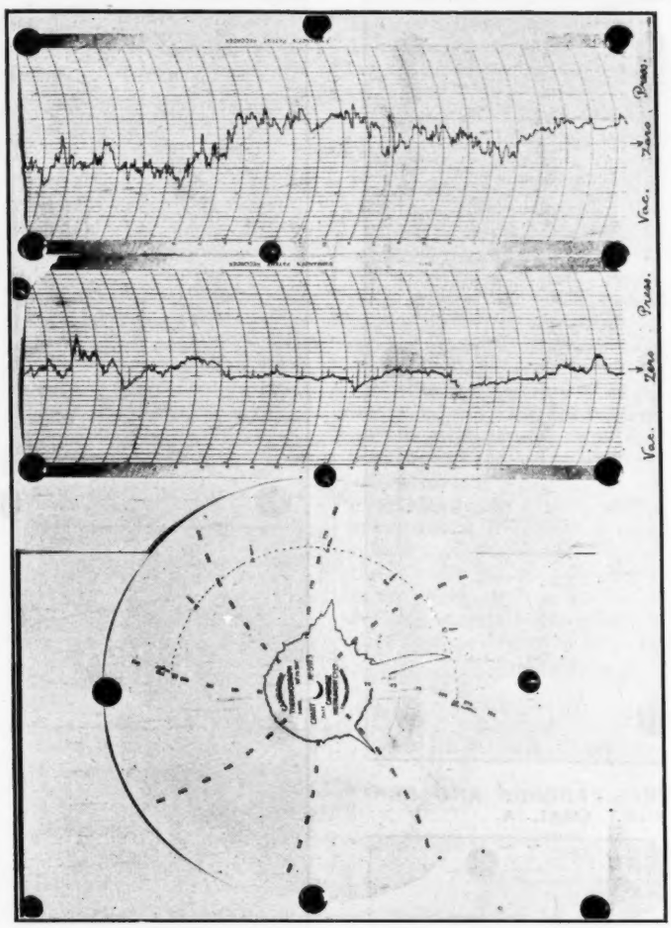


FIG. 10.—BOTTOM PRESSURES. POROUS (1) AND NON-POROUS (2) CHARGES. COAL B. ALSO OFFTAKE TEMP. POROUS CHARGE.

swelling coal ("B") at approximately a 6-ton throughput and the same steaming conditions (10 p.ct.). The results are given in Table IV.

Here, again, the large coal makes smaller coke. The retort worked better than on the crushed coal (90 p.ct. through 2-in. screen), which is usually very troublesome. The comparisons of bottom pressures can be made from typical records for crushed and graded coal in fig. 10, which also gives the gas off-take temperatures for graded coal. It will be seen that both bottom pressures and off-take temperatures show some advantage in the working of the large coal, but not to such a marked degree as with coal "A." It is fairly obvious that a swelling coal like "B" will cause loss of gas into the flues, due to local pressures—especially with crushed coal charges and leaky retorts.

Effect of Temperature on Coke Size.

This is well exemplified in the results in Table V. for coal "A" working with (1) high top heats and high bottom heats, and (2) high top heats and moderate bottom heats, and the same rate of throughput.

The effect is appreciable, but not so marked as the effect of coal size. Higher temperatures make smaller coke and more dust.

Effect of Percentage of Steam on Coke Size—Coal "A."

With ordinary crushed coal (90 p.ct. through 2 in. screen) this was not very noticeable, but with large coal (3 in. by 1¼ in.) appreciably increased the amount of dust.

The results lend some support to the view that, with ordinary crushed coals, even moderate swelling coals, very little steam finds its way into the body of the charge.

Strength of Coke.

A successful attempt has been made to use a shatter test for distinguishing between the sensitiveness to breakage of various cokes. The American method, described in "Fuel" by G. E. Foxwell and R. V. Wheeler (1925), p. 355, was first used, whereby 50 lbs. of coke are allowed to fall 6 ft. four times, and are graded to ascertain the degree of breakage. This gave very discordant results, and insufficient discrimination between the cokes. A modified form was used, and 50 lbs. of coke of a uniformly graded size (2 in. by 1¼ in.) sq. mesh allowed to fall three times from a box with trap door down a vertical chute 19 ft. long, of square cross-section, 16 in. by 16 in., on to an iron plate. This method gave reasonably concordant results, as will be seen from the following three sets of duplicate tests showing percentage gradings after shattering.

TABLE VII.—*Reproducibility of Shatter Test Results.*

Size of Coke after Shatter.*	1.		2.		3.	
	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.
2 in. by 1¼ in. . .	46·0	44·0	42·4	43·5	39·6	39·6
1¼ in. by ¾ in. . .	39·6	40·5	43·6	41·8	45·0	45·4
¾ in. by $\frac{7}{16}$ in. . .	6·2	6·5	7·5	8·4	8·5	9·0
Below $\frac{7}{16}$ in. . . .	8·2	9·0	6·6	6·3	6·9	6·6

* Original size of coke 2 in. by 1¼ in.

The amount of breakage is a function of the strength and density of the coke; the impact per unit volume being greater with the denser coke. Using this test, we found that the coke from a porous charge of large coal deteriorated quickly with increase of steam, whereas that from smaller coal was much less affected.

The selection of a particular grade for testing may be open to some criticism, though it gave concordant results, which should be comparable.

Swelling of Coal in Relation to Dimensions of Void Spaces in Charge.

The percentage swellings of coals "A" and "B," as

TABLE VIII.—*Effect of Steam on Strength of Coke.*

Steam.	Tons.	*Grading after Shatter. (Percentages by Weight.)			
		2 in. by 1¼ in.	1¼ in. by ¾ in.	¾ in. by $\frac{7}{16}$ in.	Below $\frac{7}{16}$ in.
Coke (from Coal "A," through 3 in., over 1¼ in.).					
10·5	6·4	54·0	37·0	4·0	4·9
15·0	6 3	40·5	46·5	4·0	9·0
Coke (from Crushed Coal "A," 90 p.ct. through 2 in. screen).					
8·6	..	52·0	36·9	4·9	6·2
16·8	..	51·5	38·5	4·0	6 0

*Original size of coke, 2 in. by 1¼ in.

determined by the method given in Section III., are 22 p.ct. for "A," and 100 p.ct. for "B." The yields by weight of dry coke determined on horizontals are 60 p.ct. for "A," and 67 p.ct. for "B."

When considering the porosity of a charge from the point of view of gas passage, the dimensions of individual voids are of primary importance. Very small individual void spaces make very narrow gas channels, and offer such resistance that the charge is practically non-porous, and the plastic layer in the carbonizing zone has every chance of forming a continuous or unbroken layer preventing passage through it of ascending gases. The large void spaces in a charge of cobble coal take much more choking-up either by swelling or deposition of tar; and therefore the plastic layer in the carbonizing zone is much more likely to be discontinuous or broken, thus allowing ascending gases to pass through it.

While discussing porosity, attention may be drawn usefully to the fact that if the coal consisted of spheres of uniform diameter there are two limits to the volume of voids or pores, depending on the packing arrangement of the spheres. For rectangular packing the voids = 47·6 p.ct., and for triangular packing 25·9 p.ct., of the total volume. These limits are unaltered whatever the diameter of spheres, so long as all spheres have the same diameter. The introduction of suitable smaller spheres into a mass of large spheres obviously reduces the volume of void spaces. The voids in the two coals "A" and "B" graded to pass through a 3 in. and remain on a 1¼ in. screen had a volume of 46·5 p.ct. of the total volume of coal *plus* voids (determined by water displacement of air on a 1·25 cwt. sample). These coals, mixed with fines, have considerably less void space, and the dimensions of individual void spaces are much smaller.

With coal as usually crushed for carbonizing, a small amount of swelling soon makes the individual voids so small that the charge becomes impervious to ascending steam and blue water gas, &c. With large coal from which the fines have been separated, the heating is done largely by ascending hot gases, and, owing to the counter-currents of coal and gas, is more uniform and gradual than by heat transmitted from the walls. The coals, therefore, are unlikely to swell to the extent determined by external heating where the muffle was raised 7° C. per min.

Even with the degree of swelling given by the latter test, a charge of coal "A," 3 in. by 1¼ in. grade, would remain porous; but a charge of coal "B" of similar size would soon become non-porous, the void space available only allowing an 87 p.ct. swelling. This swelling is somewhat modified by the internal gaseous heating; but if this method of internal heating is interrupted, in all probability the charge will become non-porous, due to the increased swelling caused by external heating.

SEGREGATION OF COAL SIZES AND EFFECT ON CHARGE.

No doubt all engineers have frequently watched the filling of the large coal bunkers above the retort house. Those who have to use many varieties of gas coal must have been impressed with the variation in size of coal coming to the bunkers—some receiving a perponderance of lumps, and others of fines. The falling of coal into the bunkers helps segregation considerably, owing to the rolling of the larger coal to the edges of the conical heap. When the bunker empties into the auxiliary retort hopper, the bottom and central portions go first, and then the coal from the sides starts to roll down the inverted cone. Both the above phenomena result in the auxiliary hopper receiving a large proportion of smalls at one time and coarse coal at another.

The following table gives typical examples of bogies of coal drawn within a few hours from a 12-ton bunker filled with a crushed, screened gas coal, and shows the variation in size.

TABLE IX.—*Segregation in Bunkers.*

Weight of Coal in Bogie.	Coal Grading Percentages.			
	Above 2 in.	2 in. by 1 in.	1 in. by $\frac{7}{16}$ in.	Below $\frac{7}{16}$ in.
EXAMPLE 1.				
7·3 cwt.	2·0	7·4	26·4	64·2
7·8 ,, ...	7·7	48 6	30·9	12·8
Average for 12 tons .	3·2	35·1	33·8	27·9
EXAMPLE 2.			Below 1 in.	
Approx. 8 cwt. . .	2·4	46·1	51·5	..
,, 8 ,, . . .	7·5	74·2	18 3	..

A further segregation of the coal takes place as it feeds into the retort. For example, with the present standard design of top ironwork on the Coal Test Works, where the coal travels over the sloping base-plate of the auxiliary hopper, and each half is deflected to opposite ends of the retort, the following segregations tend to take place. The "fines" riddle through the coarse coal on to the sloping plate, and the larger coal flows to the opposite side and ends of the retort. There is thus a decided tendency for the charge passing down under the sloping base-plate of the auxiliary hopper to be less porous than at the ends or opposite side. However, the chief variation in porosity is doubtless due to the varying size of coal coming from the bunkers, and this is an important factor in causing unsteady conditions in the retort. The rate of carbonizing is increased with the coarse coal and slowed down with the fine coal, with resultant alteration in the position of the carbonizing zone;* and consequently the sequence of processes taking place is prevented from attaining a steady condition for more than short intervals. Add to this the effect of the different varieties of gas coal which some works are compelled to use, and one realizes the difficulties in the way of obtaining that desirable object with any continuous process of carbonization—viz., a charge of regular composition and physical condition.

The effect of sporadic choking of the gas passages in the retort due to segregation restricts the ascending gases to particular channels, and this concentration of hot gases causes local heating and local pressures. The raw coal at the top of these channels becomes overheated and sticky—a condition somewhat similar to "rat holing" in producers. This condition often happens up the end walls of a retort, where the charge tends to be more porous, thus offering a passage for ascending gases. If the coal in the lower part of the top ironwork is made sticky by the concentrated hot gases, the flow of coal to this end of the retort is interrupted, and the retort becomes partially empty. When this condition occurs, the charge appears red when viewed through the end rodding-holes, and may be hollow more than half-way down.

Varying porosity of charge interferes with regular heat absorption, and helps to upset the distribution of heats.

When the charge is non-porous, the steam-carbon reaction takes place chiefly up the ends and sides, and this keeps the lower half to two-thirds of the retort free from scurf. A certain amount of water gas is probably formed by endothermic reactions such as $CH_4 + H_2O = CO + 3H_2$ in the higher regions of the retort, thus destroying valuable enriching gas.

RELATIONS BETWEEN COAL SWELLING, RETORT VOLUME, AND THROUGHPUT.

The retort used in the present tests had capacities per 1 ft. vertical height as follows:

	Expansion over Top. P.Ct.
First 4 ft. down— 4·6 c.ft. per vertical ft. . . .	—
From 4 ft. to 9 ft. down—6·4 ,, ,, ,, . . .	40
From 9 ft. to 14 ft. ,, —7·3 ,, ,, ,, . . .	58
From 14 ft. to 25 ft. ,, —8·3 ,, ,, ,, . . .	80
Total volume = 178 c.ft.	

The retort is designed so that as the charge descends it has room to swell. Taking coals "A" and "B," which

* Temperature records taken in the charge with base-metal couple and thread recorder show that the isothermal lines move up and down several feet, due to such causes, in the course of a day.

represent widely-used types of gas coal, the allowance for expansion is excessive for "A," and scarcely enough for "B." When "A" is being used, it will tend to leave a free space up the sides of the retort, allowing the accumulation of scurf, which rapidly causes modification in retort volume. It does not appear practicable to design a retort to deal equally satisfactorily with coals differing in swelling properties like "A" and "B" when they follow one another into the retort sandwich fashion. Obviously, such dissimilar coals should not be used unless thoroughly well mixed.

With the more voluminous coke from coal "B," and also larger percentage yield, it follows that for the same throughput the extractor must eject a larger volume for "B" than for "A." Therefore, if "A" follows "B" into the retort, it will most probably be passing down too rapidly, with the result that, although it may be denuded of volatile matter, its thermal yield is low, owing to the carbonizing zone being too low down, resulting in a longer travel over hot surfaces, and consequent degradation of the gas. We have had several instances showing that, when the throughput for coal "A" exceeds 6·5 tons, the thermal yield of gas falls rapidly, though the coke is not high in volatile matter. The above furnishes another reason for thoroughly mixing coals, as such erratic occurrences cannot be corrected for by extractor adjustments.

Effect of Method of Coal Feed on Working of Retort.

Design of Coal Feed.—We have made tests on several designs of coal feed (top ironwork) in Birmingham on both the Coal Test Works and the large works, with a view to deciding the effect of top ironwork on travel of coal into and through the retort. No design has been found better than the existing ones—largely due, the author believes, to our not quite appreciating the effect of variation in sizes of coals.

One important principle did emerge from the tests—viz., tar-laden gases should not come into contact with cold coal in the top ironwork. When this happens, not only does the coal get sticky with tar, but if for some reason the upcoming gases are confined to a restricted channel and come up at high temperature, they tend to cake the coal in the top ironwork, which leads to trouble. For this reason, designs which allow the gas to pass away with minimum contact with coal in the top ironwork give the best results.

The usual feeding of the retort from one side has always struck the author as a method of doubtful merit, as it chokes the top exits for the gases and steam coming up that side of the retort, and tends to drive them to the ends or any other channel of less resistance. There are two alternatives:

(1) To have the auxiliary hopper symmetrically disposed along the major axis, whereby the coal rests on the charge, and the gases are free to come off both sides of the retort.
(2) To have the charge kept down in the brickwork and regularly fed with coal.

No. 2 did not seem to be a good arrangement, as it would help to consolidate the charge along the carbonizing zone; however, it was given a trial at our Windsor Street Works, along with other designs, but showed no improvement, partly because of the above action, and partly because of the variation in coal sizes caused by segregation, &c.

Keeping Charge Below Top of Retort Brickwork.—In the second method, the charge was kept about 18 in. below the brickwork, and filled up at twenty-minute or half-hourly intervals, using the top half of the auxiliary hopper as a measuring chamber after suitable modification, and keeping the remainder empty. By this means the retort worked as long as 36 hours without rodding on the swelling coal "B;" but the thermal yield was poor, owing to the human element, leakage in top ironwork, and the rush of gas which accompanied each fresh charge as it entered the retort—the charge having been allowed to get too low. It should not be impracticable to design an easily-controllable continuous feed to the retort, so as to keep the charge in the brickwork at any desired level, using some form of dipping-rod to ascertain the level of charge. The experiments suggest that it would considerably reduce the rodding. There is no satisfactory reason why it should not give good thermal yields under the right conditions of control.

Effect of Horizontal Heat Zoning on the Working of Coals "A" and "B."

1.—*High Throughput v. Low Throughput.*
2.—*Top Single-Stage Heating v. Two-Stage Heating.*

With the highly-swelling coal "B," it is very necessary to regulate the throughput and temperature so that the carbonizing zone is neither too high up nor too low down the retort, otherwise the allowance for swelling is not made the best use of. It is found, for example, that if coal "B" (crushed 90 p.ct. through 2 in. screen) is worked at 4½ tons throughput per day with top single-stage heating, it is carbonized too high up in the retort, and not having room for expansion makes a dense large coke which is difficult for the extractor to deal with. If the rate of throughput is increased to 6 tons, the working is somewhat better; and if, in addition, the retort is put on two-stage heating, the difficulties are further reduced, and results considerably improved.

The probable explanation is as follows: First, the degree of swelling of a coal increases, the more rapidly it is heated (within limits), so that high top heats tend to produce maximum swelling at the top. Again, as the coal passes down the retort, the head of heat in the combustion flues is falling, and also the heat has to pass through an increasing thickness of coke before it reaches the carbonizing zone. It follows, therefore, that the coal lower down is heated more slowly than that higher up, and does not swell so much. This will cause a more rapid descent of coal down the centre than the sides. Two-stage heating, implying moderate top heats, tends to correct this.

Secondly, increased rate of throughput, besides helping to adjust the carbonizing zone to the right position for making the best use of retort dimensions for swelling, has two other important consequences:

(1) It keeps the charge more on the run, and gives the pasty coal at the top less chance of adhering or gluing itself to the sides of the retort.
(2) It makes smaller coke.

Tenacity With Which Coals Stick to Refractories.

The tenacity with which different coals adhere to refractories and scurf is receiving attention. It certainly differs very greatly with coals "A" and "B."

Fig. 11 illustrates a simple experiment in which coal "B" in powder form was slowly heated to 500° C. between two refractories, held there for about half-an-hour, and then cooled. A pull, normal to the surface, of 16 lbs. to the sq. in. was required to break the joint. A similar test on coal "A" showed it had very poor jointing properties. This experiment indicates the serious sticking likely to occur if there is any interruption in

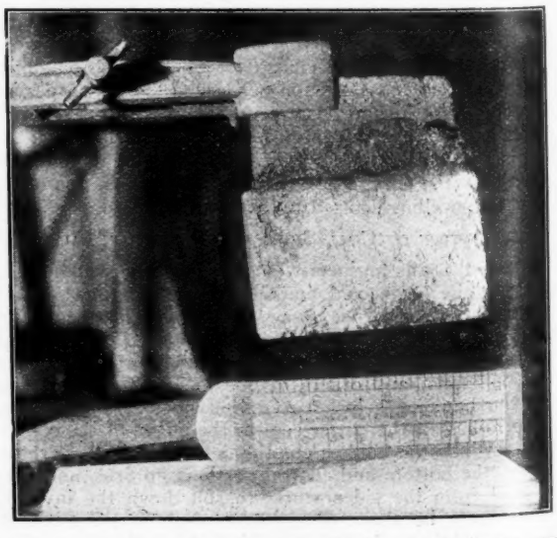


FIG. 11.—STICKING OR JOINTING PROPERTY OF COAL B.

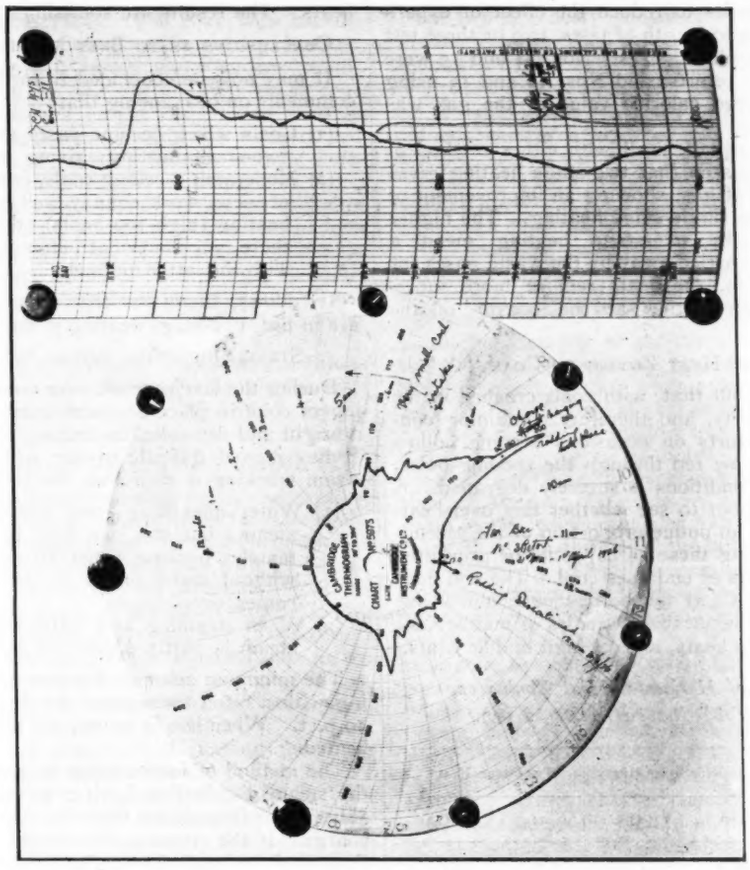


FIG. 12.—EFFECT OF "HANGING" CHARGE ON OFFTAKE TEMP. AND C.V.

At Station Meter (45 Mins. Later).

descent of the charge. In this connection, it is worth mentioning that the extractor works on a continuous-intermittent principle—*e.g.*, extracting 25 seconds out of every 60 seconds—and allows the charge to descend over each successive portion of a cross-section, starting at the middle of the major axis and proceeding outwards. The charge moves downwards, not as a whole, but in successive vertical sections; and as a consequence a slipping or faulting action proceeds intermittently across the plastic carbonizing zone in common with the rest of the charge. This action tends to produce a succession of breaks in the carbonizing zone, and prevents it becoming one rigid whole. The quicker the throughput, the more frequent the breaks and the smaller the coke. This is very noticeable with coal "B."

The possible relationships between the mode of descent of charge and coke structure are briefly touched upon at end of Section III. of the paper.

A really continuous extraction may improve working, by reducing the chances of sticking.

Top Heating and Scurf Formation.

Top heating with coal "B" (crushed) led to a formation of scurf 3 in. thick on the end walls and 2 in. on the side walls, after three weeks' working; then scurfing had to be done. With two-stage heating, the retorts worked four weeks on "B," *plus* five weeks on "A," before scurfing was necessary; and then the scurf was only 2 in. thick as a maximum.

Rich Swelling Coal, and Steam Required to Give Desired C.V.

The improvement in ease of working which we have seen can be brought about by increasing the daily throughput of "B" to 6 tons is considerably offset by the excessive steaming required to reduce the rich gas (by B.W.G.) to the desired C.V. of 475. It was not possible to get as low as this, even with 30 p.ct. of steam; and with reasonable steaming—(say) 15 p.ct.—the C.V. most readily obtained was approximately 500 B.Th.U. gross.

Taking all considerations of ease of working into account, a rich swelling coal like "B" is not so suitable for continuous verticals by itself where a C.V. of much less than 500 B.Th.U. gross is required, as coal "A."

"Rodding" of Charges.

With present-day methods of charging, where the retorts receive varying types of coal, unmixed, and of varying sizes, systematic rodding has proved very necessary. The efficacy of rodding, unfortunately, depends upon the skill and conscientiousness of the stoker. Careful rodding is especially important with a fusible swelling coal like "B." Such a charge soon gives trouble if neglected, and takes much more rodding to correct than a charge of coal "A." Carelessness or neglect in rodding is a very potent cause of retort trouble; and even one careless hand in the gang can greatly reduce retort house efficiencies. In Birmingham, we have tried rodding every two, three, or four hours; but after taking our various conditions into consideration, including the human factor, we have returned to hourly rodding as the safest to adopt.

Tests have also been made to see how long a retort will work without rodding on coal "A." In one test the charge worked eighteen hours; but at the end of that period it was obvious that the whole charge was hanging-up, as is strikingly indicated by offtake temperature and C.V. record in fig. 12. It took four hours before the retort became properly charged again, and it would take about sixteen hours for the retort to get really into stride; and this was using only a moderate swelling coal.

Effect of Horizontal Heat Zoning on Results from Coal "A."

In Table X. are given typical results obtained with the heat in the combustion flues distributed in two ways:

(1) Top single-stage heating (using only top CO ports).
(2) Two-stage heating (using both CO ports). (See Section I.)

Two percentages of steam were used for each method of heating; and in order to reduce the effect of experimental error in relation to length of tests, two or three test periods have been combined. Tests Nos. 14 and 15 were carried out using two retorts, and Nos. 12 and 13 using one retort. The desired calorific value of the gas was 475 B.Th.U. gross.

The charge works equally well with either method of heating; but it will be seen that two-stage heating gives the best thermal yield of gas, showing an improvement of about 2½ p.ct. over top single-stage heating. The higher bottom heats given by two-stage heating mean a larger amount of heat carried away by the waste gases for steam generation; also, the heats require more supervision to prevent over-heating at the bottom of the retorts.

EFFECT OF VERTICAL HEAT ZONING ON COAL "A."

It has been pointed out that, with coals crushed in the usual way for the retorts, and therefore containing considerable fines, the retorts on occasions become hollow down the ends, and show red through the rodding-holes. The gas under these conditions is severely degraded. A few tests were carried out to see whether this over-heating at the ends (due to an undue proportion of the ascending gas and steam taking these paths) could be prevented by keeping the two pairs of end flues cool. The end flues were reduced to 1000° C. at the hottest part, and below 900° C. at the bottom, while the two pairs of middle flues were put on (1) high top heats, and (2) high middle heats.

TABLE X.—*Effect of Horizontal Heat Zoning on Results. Coal "A" (90 p.ct. below 2 in.).*

Heating	Top-Single Stage Heats.		Two-Stage Heats.	
Tests	12.	13.	14.	15.
Percentage steam	10·3	13·9	9·0	13·1
Temperatures, ° C.—				
Tops, 7 ft. down	1410° C.	1368° C.	1250° C. *	1250° C. *
Middles, 13 ft. down	..	..	1380° C.	1367° C.
Check tiles, 20 ft. down	1007° C.	1050° C.	1231° C.	1220° C.
Total coal	55·8	53·4	63·4	52·5
Per day	6·19	6·13	12·26	12·35
Per retort	6 19	6·13	6·13	6·17
Make per ton	16,120	17,220	16,660	17,600
Calorific value, gross	478	463	475	470
Therms per ton	77·1	80·0	79·2	82·6
Tar, gallons (dry)	11·7	13·3	13·9	15·6
Liquor, 10 oz.	30·0	32·4	30·3	33·0
Gas analyses—				
CO_2	4·0	4·6	4·2	3·6
HC	1·6	1·5	1·3	1·2
O_2	0·2	0·3	0·2	0·4
CO	17·4	17·6	17·2	17·4
H_2	52·3	51·5	51 1	51·3
CH_4	19 6	18 6	18·9	19·6
N_2	4·8	5·8	7·0	6·5
Coal analyses—				
H_2O	6·4	5·2	5·3	6·6
Ash	8·7	8·6	7·7	8·8
V.M.	33·6	34 5	35·9	34·8
Coke—				
V.M.	2·4	2·4	2·5	2·0

* Approximate.

NOTE.—Tar quantities cannot be stressed. The refined method of measurement outlined in Section I. had not been devised when these tests were carried out.

The results reflected the effect of lower temperatures—viz.:

(1) Relatively low gaseous therms as compared with normal working.
(2) Large coke, causing trouble on extractor and erratic working of retort.
(3) Incompletely carbonized coal, bringing average volatile matter up to 4 p.ct.
(4) High calorific values owing to insufficient dilution with blue water gas, which, in turn, was due to reduced temperatures at check-tile level.
(5) High ammonia yields.
(6) Increase in unsaturated gaseous hydrocarbons.

The difficulty in working demonstrates the importance of maintaining the same heat intensity and distribution in all combustion flues. It is desirable that not one or two, but all, combustion flues receive periodic inspection for heats. The results are sometimes surprising.

CONCLUSIONS AS TO BEST METHOD OF HEAT ZONING.

It may now be concluded from the preceding tests and comments on heat zoning that:

(1) Coals which become pasty and swell work best on two-stage heating, giving moderate top heats.
(2) Moderately swelling coals, from the mechanical point of view, work equally well with either single-stage heating (high top heats) or two-stage heating, but there is a somewhat better yield of gaseous therms with the latter method.

It follows, therefore, that, where both classes of coal are in use, two-stage heating is the best to adopt.

STEAM QUENCHING *versus* WATER QUENCHING.

During the last year we have resorted to steam quenching of coke in place of water quenching. This produces a bright and dry coke, containing 1 p.ct. or less of water. It has proved difficult to say whether the efficiency of steam cracking is improved, for two reasons:

(1) Water quenching itself provides about 5 p.ct. of steam; but this can only be determined approximately, because when attempts are made to run without water or steam the bottom ironwork becomes over-heated.
(2) When steaming and water quenching, the ingoing steam is partly condensed by the water sprays

The minimum amount of steam to give efficient quenching with a 6-ton throughput we find to be approximately 10 p.ct. When less is in use, the ironwork becomes over-heated.

The method of introduction to give the best chances of the steam distributing itself evenly in the retort is probably of less importance than the degree of porosity of the charge. If the steam is introduced at one or more positions in the curved plate under the extractor, the inlets are apt to become choked, whereas this is less likely when it is introduced in the coke chamber. Apart from this, we have no sufficient evidence to show whether one place is better than the other as regards cracking efficiency.

One objection to steam quenching is the dust which blows about when coke is discharged; it would be worth while counteracting this, if possible. The improved dryness and appearance of the coke is a strong argument in favour of steam quenching.

MANUFACTURE OF BLUE AND CARBURETTED WATER GAS IN VERTICAL RETORTS.

It is generally appreciated that the cracking of horizontal tars in some form of water gas plant does not produce an economic quantity of enriching hydrocarbons, but chiefly hydrogen and carbon. It seems possible, however, that some of the semi-low-temperature tars produced in steaming verticals may yield a profitable amount of enrichment.

Dr. E. W. Smith suggested that an experiment worth trying would be to to make blue water gas in a vertical retort by steaming a charge of screened coke, and attempt to enrich this by introducing ordinary vertical tar into the top zone of the retort. Preliminary tests on this have been carried out, but are not yet completed. Coke, graded to pass through a 2 in. and over a 1 in. screen, was fed into the retort, and the extractor worked very slowly, to extract about 1 cwt. per hour. The extracted coke was used in the producers. The retort was on two-stage heating, giving 1350° C. in the hottest zone, and 1150° C. at the bottom. No fuel consumption test was made; but it was found necessary to get the maximum supply of producer gas and air (correctly proportioned) to the retort to maintain temperatures. No cooling was noticed during tar or oil cracking. Steaming was at the rate of 130 lbs. per hour, and resulted in a "make" of 3500 c.ft. per hour of water gas having a calorific value of 290 B.Th.U. (We have since made 4000 c.ft. per hour.)

Vertical tar, introduced through a 2 in. pipe reaching 12 ft. down the retort, gave practically no enrichment, and the pipe became blocked with lamp-black and pitch. When the pipe was shortened to 6 ft., a certain amount of enrichment was obtained. The gas equalled 3700 c.ft. per hour; tar 13 gallons per hour = 3·5 gallons per 1000 c.ft.,

and calorific value 326 B.Th.U. The coke was heavily coated with lamp-black, showing excessive degradation. Assuming that the tar will enrich under proper conditions, it is obvious that we had not hit upon those conditions. The tar requires a proper distributing feed in the top of the retort—possibly a series of water-cooled tubes as used at the Fuel Research Station in their work on oil enrichment in verticals (Technical Paper No. 14).

In order to get some standard of enrichment to judge from, we tried enrichment with gas oil, using 5·5 gallons per hour = 1·34 gallons per 1000 c.ft. for a make of 4090 c.ft. per hour. Average calorific value = 374 B.Th.U. The calorific value should have been in the region of 430 B.Th.U to equal results in the usual carburetted water gas processes.

The work is being repeated under improved conditions of tar feed, &c. The author understands that similar tests are now in progress at Bolton under Mr. W. J. Smith, and the results will be awaited with considerable interest.

Possible Alternative Method of Scurfing.

Apart from making carburetted water gas, and thus relieving a proportion of other retorts from full steaming, there is considerable prospect that the work will lead to the development of a method of scurfing without emptying and burning-off. This latter operation is not good for the retort, and can be a source of serious damage. It also entails a 7 to 10 p.ct. loss in plant capacity. The filling-up with coke will mean some slight modifications in the top ironwork—possibly a slide in the auxiliary bunker to receive coke from the supply used for starting-up retorts, unless the coal bunker is used.

We have been trying a method of running the retort very slowly on coal and steaming normally. This led to a considerable reduction in scurf, but brought in its train another difficulty—the coal in the auxiliary hopper became heated and caked. This was overcome by shot-pouch feeding the retort, and keeping the charge just below the brickwork; how far this is safe or practicable on a large installation is a matter of doubt.

SECTION III.
METHODS.

Sampling and Analytical Methods, &c. Coal Swelling.

Coal Sampling.—The best opportunity for sampling coal is after it has been broken fairly small (*e.g.*, 90 p.ct. through 2 in. screen), and is being conveyed in a relatively thin stream from one point to another. It is then necessary to devise some arrangement for taking a portion of coal from the stream at regular intervals. There are two vital points to bear in mind, to ensure a truly representative sample being obtained:

(1) A sufficient number of portions shall be taken, and each shall be a complete cross-section of the stream, so that no possibility of selective action arises, such as that due to segregation of sizes along the edge of the stream.

(2) A sufficiently large bulk sample shall be taken.

The best device, incorporating the first point, will vary according to the mode of coal transport—*e.g.*, with a gravity bucket conveyor the sample can be made up of buckets made to tip at definite intervals.

In our particular case, after trying various arrangements, we find it most convenient to use a horizontal rotating coal valve working in the bed of the sloping chute from the top of the bucket elevator. The valve consists of a 12 in. diameter cylinder extending right across the bed of the chute. The cylinder contains a V-shaped pocket parallel to its axis, and capable of holding about 2½ lbs. of coal. This is rotated in a direction opposite to the coal stream by rapid jerks, so that it is fully opened by one jerk and closed by the next. When the V pocket is uppermost, it is filled instantly by coal shot in from the elevator buckets; and this is delivered into a funnel and 6 in. pipe leading to a Sturtevant crusher. This latter delivers a pre-determined proportion of its charge to a disc grinding mill, which ensures disintegration of the coal to less than $\frac{1}{16}$ in. mesh sieve. The sample is then quartered down to 10 lbs., and three 2 lb. samples taken, two of which are sent to the laboratory, and one reserved. The quantity of sample taken by the sampler is approximately 4 p.ct. of the whole of the coal.

The two laboratory samples are treated as entirely separate samples; and duplicate results are thus obtained. The samples are further ground in an end-runner mill until they pass through a 60-mesh sieve, and then analyzed for ash, volatile matter, sulphur, soluble salts, &c., using the methods approved by the Fuel Research Board—*e.g.*, volatile matter and ash in electric furnace at 900° C.; calorific value by Mahler-Kroeker bomb calorimeter. Care is taken not to expose the fine coal to air unduly, in order to prevent oxidation.

The sampling scheme ensures that the final sample is as representative as possible, and is considered of primary importance in our coal testing.

Moisture in Coal.—The author always has grave doubts as to the accuracy of moisture determinations done on 100 grammes or so in the laboratory. It is our practice to take from the truck while unloading, or from the bunkers, a 1 cwt. sample of coal as representative as possible. This is weighed in a shallow tray to the nearest ½ oz., and then dried for 12 to 24 hours in a steam-heated oven, kept at 105° C.; a thermograph record being taken each time. The oven is made in sheet iron, with suitable vents in the top, and carries four trays. Steam pipes run along the sides and under the bottom, serpentine fashion; and steam up to 80 lbs. pressure is used. Remarkably uniform temperatures are obtained, and the method, where practicable, is without doubt far preferable to the usual laboratory method, as it eliminates the time taken to obtain the small sample, during which the moisture content is very liable to alter.

Coke Sampling.—The sample consists of an entire quarter-hour's extraction, varying from ½ to 1 cwt., according to the rate of working. Careful experiment showed this to be the minimum collection which gives consistent results. When shorter samples were taken (say, 5 minutes), they were unduly high in ash, which could not be accounted for, but has since been attributed to the shaking-down in the retort (by the jerk of opening the coke discharge door) of the ash exposed by the steaming on the face of the charge. Apart from moisture, which was done in the large oven, the determinations were made according to the methods recommended by the Fuel Research Board.

Tar Sampling.—Tar is one of the most difficult substances to sample for water content. An aliquot part is taken from each sampling cock on the special receiver mentioned in Section I. Distillation is carried out in the Birmingham Gas Department type of 3-gallon still adopted and described by Dr. Parker (Gas Investigation Committee, Fourth Report). Much interesting work is being carried out on tars, but space prevents the results being included here.

Liquor Sampling.—This is taken through a small sampling pipe which taps the liquor as it is being run away to the storage wells on the large works. Every precaution is taken in determining the ammonia by distillation with caustic soda into standard sulphuric acid.

Gas Sampling, C.V. Testing.—As stated in Section I. of the paper, the stream of coal gas can be sampled directly off the retort, and again at the outlet of the station meter (10,000 c.ft. per hour). At the first point it is, of course, hot crude gas, which is drawn by a small roto-plunge pump A through 24 ft. of 1¾ in. diameter iron piping (air condensers) B—see fig. 13—and then driven through the following train of scrubbers, &c.

C.—*Condenser Scrubber.*—An iron cylinder 2 ft. long, 4 in. diameter, filled with broken glass.

D.—*Washer.*—An iron cylinder 18 in. high, 6 in. diameter, containing water through which the gas bubbles.

E.—*Tar Catch.*—An iron cylinder 7 in. by 3 in., kept empty to act as tar catch.

F.—*Purifier.*—16 in. long by 6 in. diameter, containing graded oxide of iron (in duplicate to allow for changing oxide).

G.—Bottle containing cotton wool.

H.—Small water-cooled condenser.

From here the gas supplies a recording calorimeter, a Junkers flow calorimeter, and a 10 ft. sample holder (not depicted). Considerably more gas than is required for testing is drawn from the retort by the exhauster, and

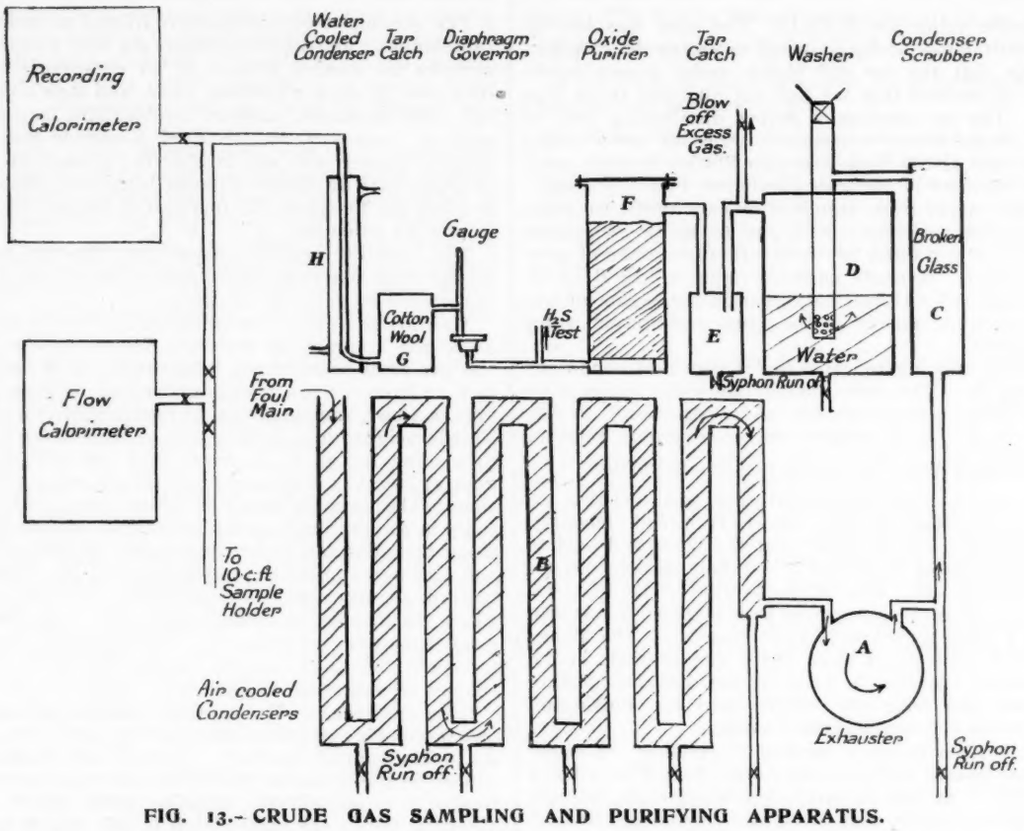


FIG. 13.- CRUDE GAS SAMPLING AND PURIFYING APPARATUS.

the excess is blown off at the outlet of the water bubbler, item D, above. This practically eliminates the lag which would otherwise occur owing to the volume of the apparatus. There is very little volume in the remaining parts, and the calorific value on the recording calorimeter is not more than five minutes late. The apparatus A to H is fixed on a portable stand, and can be taken to any desired place in the retort house. Alternatively, it can be fixed in a central position, and gas piped to it.

The agreement between the gas obtained from this small purifying equipment and the gas after passing through the Coal Test Works scrubbers and purifiers, is seen from Table XI. to be very good. The large sample was started 45 minutes later, and stopped 45 minutes after the small one, to allow for the time taken by the gas to pass through the Test Works scrubbers, purifiers, &c.

The agreement between the recorders, allowing for time lag, is seen in figs. 7 and 8. Note how the small fluctuations are smoothed-out by mixing, in the large scrubbing and purifying plant.

GAS ANALYSES.

Control analyses are carried out in the Birmingham modified Orsat, which includes a heated copper oxide tube for determining nitrogen. Complete analyses are done daily on samples collected over mercury (from the holder samples), using the Bone and Wheeler apparatus, with the addition of the Birmingham 1917 modification of Jaeger's method of determining CH_4 and hydrogen over heated copper oxide tube.

DETERMINATION OF SWELLING OF COAL.

Swelling Test.—In speaking of the swelling of a coal, it is important to state the conditions under which it is heated and the type of container. Many tests have been carried out on the following lines :

(1) Heating the coal slowly and regularly to a particular temperature—somewhat akin to vertical retort practice.
(2) Plunging the coal into the furnace already at the desired temperature—somewhat akin to horizontal retort practice.
(3) Repeating Nos. 1 and 2 with coal in briquette form (without addition of binder), in order to eliminate any masking effect of the container.

The effect of the container—*e.g.*, a cylinder—is very marked with easily fusible coals, because the viscous coal

TABLE XI.

Date, 1926.	Samples in 10 C.Ft.								Samples in 200 C.Ft.							
	Hours.	C.V.	CO_2.	HC.	O_2.	CO.	N_2.	Inerts.	Hours.	C.V.	CO_2.	HC.	O_2.	CO.	N_2.	Holder Inerts.
April 2. .	10.45– 5.15	433	1·6	0·9	*Nil*	23·9	7·7	9·3	11.30– 6. 0	441	1·5	1·2	0·3	22·3	8·2	10·0
	5.45– 2.15	437	2·1	1·0	0·2	21·5	8·8	11·1	6.30– 3. 0	443	2·0	1·0	0·2	21·2	8·6	10·8
	3. 0–10.15	465	2·0	1·1	0·4	19·3	6·9	9·3	3.45–11. 0	462	1·9	1·1	0·2	19·8	6·5	8·6
	Average .	445							Average .	449						
April 3. .	10.45– 5.15	471	2·2	1·3	0·5	18·8	5·2	7·9	11.30– 6. 0	476	1·7	1·0	0·2	18·6	5·5	7·4
	5.45– 2.15	456	1·9	1·0	0·4	18·9	6·7	9·0	6.30– 2.45	459	1·9	1·1	0·3	18·8	6·9	9·1
	2.35–10.15	491	2·1	1·1	0·5	17·0	4·9	7·5	3.20–11. 0	489	2·0	1·2	0·3	18·2	5·4	7·7
	Average .	473							Average .	475						
April 4. .	10.45– 5.15	495	2·2	1·4	0·3	15·2	5·0	7·5	11.45– 6. 0	502	2·2	1·3	0·1	14·9	5·6	7·9
	5.45– 2. 0	514	2·2	1·5	0·2	13·3	4·3	6·7	6.30– 2.45	512	2·2	1·6	0·2	13·4	4·6	7·0
	2.40–11.10	486	3·0	1·2	0·3	14·8	4·8	8·1	3.25–11.55	490	3·1	1·4	0·2	14·6	5·6	8·9
	Average .	498							Average .	501						
	3 days' aver.	472							3 days' aver.	475						

on the top acts as a seal to the contents underneath; and when these start gassing, the contents of the crucible are lifted bodily upwards, and a large hollow space remains giving an abnormal swelling effect. This is very noticeable with coal "B."

The following method has been tentatively adopted for determining swelling: The coal is crushed until approximately 85 p.ct. passes a 10-mesh sieve, and 80 gms. briquetted without binder, under 5 to 6 tons pressure per sq. in. Its volume is determined by displacement of lead shot. The briquette is heated in a carefully controlled furnace at 7° C. per minute to 600° C., cooled, and volume again taken, then sawn in two, and the volume of the small hollow space taken and allowed for. The method gives comparable results, and for coals "A" and "B" gives a swelling for "A" of 22 p.ct. and for "B" of 100 p.ct. (See fig. 14.)

Coke Grading.—The results are averages of gradings of a number of hourly discharges representative of the coke being made. The gradings are always done under standard conditions by an experienced gang of men under careful supervision, using square mesh riddles.

Note on Some Characteristic Structures in Vertical Coke.

When carbonizing coal "B," which becomes pasty and swells, one often sees the flat pieces of shale (bats) arranged in the coke parallel to the seams of formation. Fig. 15 shows a typical example. This may be due to the action of the extractor described in Section II. causing a slipping or faulting effect in the plastic carbonizing zone, or it may be due to uneven working of the retort through sticking, and the tearing-away of the plastic layer from time to time, the flat pieces of shale being pulled parallel to the faults.

Fig. 16 is an example of a periodic structure in coke which is probably caused by the action of steam or carbon dioxide on the fractured face of a piece of coke built up of several laminæ. The more reactive alternate layers have been etched away leaving a ripple or striated effect.

One notices in cokes from certain coals (particularly in vertical coke and sometimes in crucible coke) a very fine laminated structure, of which the fracture has the appearance of edges of cards contained in a pack, which have been pushed into the form of a rhomboid (echelon formation). The individual edges can only be seen—by virtue of the light reflected from them—when the fractured face is looked at in one direction.

The mode of formation of these laminæ is probably somewhat as follows: When certain bituminous coals come into contact with the hot face of a retort, heat is transmitted fairly uniformly until a pasty layer is formed. This pasty layer interrupts to a considerable degree the flow of heat, much of which is carried away as latent heat by gases and vapours. Immediately behind this pasty layer heat is only very slowly passing into the charge, partly directly and partly as a result of the condensation of tarry vapours. This heat causes some low temperature distillation in the face of the charge next to the pasty layer. As the latter changes to semi-coke it becomes an improved heat conductor, and allows the temperature to build up in the layer which has already been subjected to low-temperature distillation. This layer, owing to the low-temperature distillation, probably does not become pasty to any great extent, and the heat is therefore able to pass more rapidly through it into the adjacent uncarbonized coal, and produce another pasty layer. Carbonization of the coal thus proceeds step by step. As each layer of semi-coke continues to carbonize, it shrinks and produces ruptures along the planes of weakness caused by the above-mentioned intermittent travel of the heat, each lamina in certain zones slightly slipping over the one adjacent. This manifestation of shrinkage is not to be confused with the well-known tension cracks at right angles to the retort wall.

The laminated structure will be profoundly affected by the nature of the coal and the intensity of heating.

Method of Showing-up Certain Features in Coke Structure.

A very useful method of showing-up certain structural features—such as disposition of bats, ash, or the varying

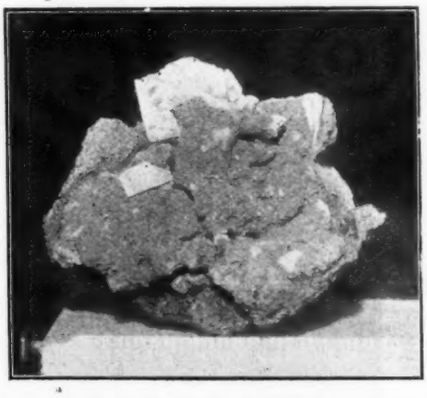
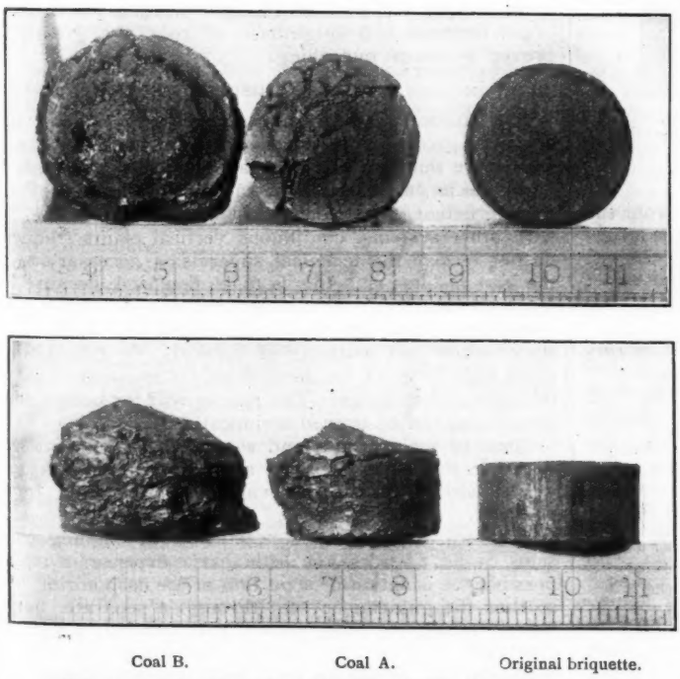


FIG. 15.—COKE WITH FLAT PIECES OF SHALE PARALLEL TO SEAMS OF FORMATION (MADE VISIBLE BY PARTIAL COMBUSTION).



Coal B. Coal A. Original briquette.

FIG. 14.—SWELLING TEST ON BRIQUETTES. COALS A AND B. (NO BINDER.)

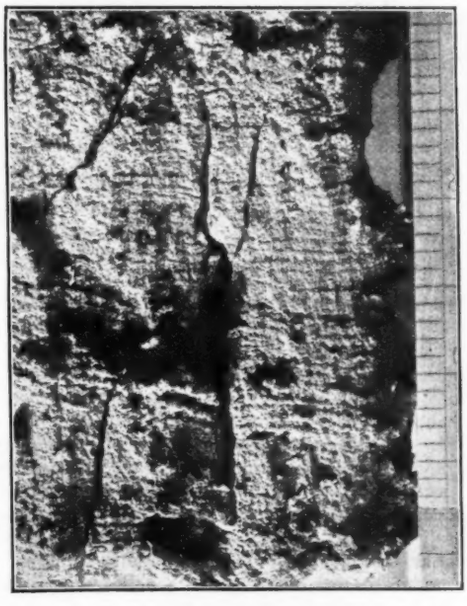


FIG. 16.—ILLUSTRATING A PERIODICITY IN COKE STRUCTURE.

combustibilities of different layers of coke—is to raise the coke to a suitable temperature, and act on it with CO_2, air, or oxygen. The method shows up certain characteristics which cannot otherwise be seen; but unfortunately the colours of the exposed ash comprise various shades of yellows, reds, and browns, and do not photograph very well. From a brief examination of horizontal and vertical coke by this method, the fine ash—apart from bats—appears to dispose itself in well-defined bands; and a study of this may throw some further light on coking (fig. 17).

SECTION IV.

SOME PRACTICAL DEDUCTIONS FROM THE PAPER.

In order to improve still further the continuous carbonization process, an attempt has been made by the author to elucidate some of the difficulties met with in practice. In spite, however, of such difficulties, Birmingham experience shows that we make our cheapest gas in continuous steaming verticals. The following deductions may be drawn from the present investigation:

1.—Good governing of gas and proper supervision of heats are of vital importance in obtaining the best efficiency in working, and in extending the life of the plant.

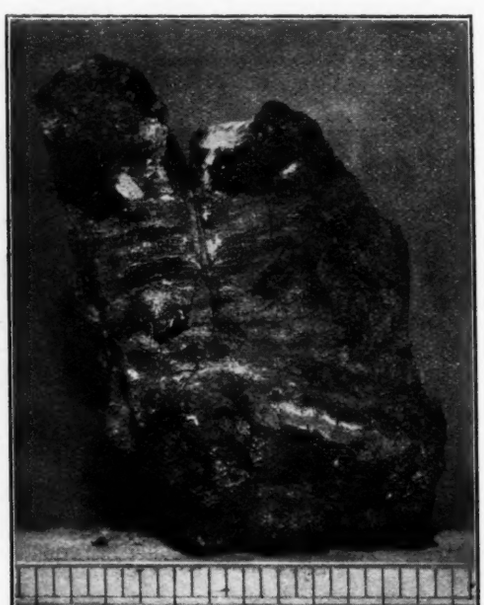


FIG. 17.—BANDED DISPOSITION OF ASH, &c. MADE VISIBLE BY PARTIAL COMBUSTION OF COKE SURFACE.

2.—Variation in coal size, either as delivered from the crusher to the bunkers or due to segregation in the latter, leads to variation in porosity of the carbonizing charge; and this causes serious fluctuations in results and retort working. This has an important bearing on design of top ironwork.

A charge of uniform grade as well as constant quality is most desirable in continuous vertical carbonization.

3.—*Behaviour of Moderately Swelling Coals Like Coal "A."*—These coals in large nut or cobble form, without fines, work more smoothly through the retort, giving improved tar and gaseous therm yields (the latter of a somewhat lower calorific value), than crushed coal containing fines. Smoother working causes less wear and tear on plant and less labour. The rate of carbonization is increased 20 to 25 p.ct., the coke is smaller than with crushed coal containing fines, and high steaming makes it more readily broken during handling (as shown by the coke shatter test). Charges work similarly with high or moderate top heats, even when using ordinary crushed coal; but moderate top and high bottom heats give a few per cent. higher yield of gaseous therms.

4.—*Behaviour of Rich Swelling Coals like Coal "B."*—These coals in cobble form work better than the crushed coal, and also give a lighter, smaller coke, which is better for domestic fires than the rather dense coke, often given by these coals. Crushed coals, containing fines, give trouble with sticking, especially with high top heats, but work rather better with moderate top heats. High top heats also cause rapid scurfing-up of retorts. Raising the throughput (within limits) improves the working of these coals, but entails excessive steaming to make a gas of calorific value much below 500 B.Th.U. Retorts using these coals should be rodded hourly to ensure uniform downward travel. Once the charge sticks, much time is taken to get it working evenly again.

Rich highly swelling coals like "B" used alone are not so desirable as the bulk of other coals for the most effective working of continuous steaming verticals, where a C.V. much below 500 B.Th.U. gross is required.

5.—Where continuous verticals and horizontals or ovens are already in existence, it is of advantage to screen the coals for the verticals over (say) a 1-in. mesh and carbonize the smalls together with certain of the highly swelling coals (*e.g.*, those which do not work with full effectiveness on verticals) in horizontals or ovens. By this arrangement, the verticals can be steamed to give a large thermal yield of lower quality gas, which, when mixed with the rich gas from horizontals, coke ovens, &c., gives a mixture of the desired calorific value. This scheme has been adopted by Mr. J. Foster (Chief Engineer) and Mr. E. B. Tomlinson (Works Engineer) at our Nechells Works, and has proved very successful. It may be necessary, however, to keep the two types of coke separate, and find separate markets.

6.—Where it is absolutely necessary to use coals of very dissimilar swelling properties on verticals, they should be well mixed or blended, and segregation of sizes prevented as far as possible. The importance we attach to this is emphasized in our Chief Engineer's decision to include large blending bunkers (holding 4 days' supply) in connection with the new installation of verticals at Saltley.

When mixing is impossible, and the coals follow one another sandwich fashion, moderate top heats are best, though loss in efficiency cannot be avoided.

7.—Preliminary tests have been carried out on the manufacture of blue water gas in verticals and the cracking of tar. This may lead to a new and more economical method of scurfing.

8.—Various methods of retort feed have been tested showing that those methods give the best results which allow the tarry gases to pass from the retort with minimum contact with coal in the top ironwork.

9.—Dryness and brightness of coke are greatly improved by steam quenching.

CONCLUSION.

The author would strongly recommend that more scope be given for technical control in the retort house. It is more than ever true to-day, with our improved, but highly technical, methods of carbonizing, that profits, to a large extent, are made or lost in the retort house. As with other systems, continuous vertical plants frequently do not receive the technical supervision necessary to get the best results; and this is to be deplored, because they respond remarkably to intelligent treatment. The author would urge that the technical supervision, both during construction and working of verticals, be raised to the same high level as has been done for horizontals in certain gas undertakings. The results will far outweigh the cost of salaries of trained technical men.

Some of the methods and recording instruments mentioned in this paper could be adopted on any works, and would without doubt give valuable information to the engineer.

Further, wherever it is practicable in building extensions or new works, the little extra expense in making possible the isolation of a portion of the carbonizing plant so that the gas can be sent through a separate, but relatively small, purifying system and metered, would give invaluable data to the engineer concerning the worth of his coals, &c., under his own particular conditions.

In conclusion, the author is conscious of having pre-

sented a somewhat sketchy picture of continuous carbonization, and does not anticipate agreement with all his deductions; but they may serve as starting-points for other suggestions. The author desires to tender his thanks to Mr. W. J. Pickering, A.I.C., Coal Test Plant Superintendent, and Mr. E. Branson, Staff Foreman. His thanks are also due to Mr. A. W. Smith, General Manager and Secretary, and to the Gas Committee for permission to publish the data contained herein.

Discussion.

The PRESIDENT: I should like to take the opportunity of tendering, on behalf of the Institution, our thanks to the Gas Committee and to Mr. Smith, of Birmingham, for allowing Mr. Rhead to present this work to us, and thus enriching the records of the Institution. As Mr. Rhead has said, he does not expect agreement with all his deductions; and no one would be more pleased than he, I am sure, if somebody would challenge his deductions.

Mr. W. J. SMITH (Bolton): Mr. Rhead has mentioned some work we have been doing at Bolton with regard to the production of water gas with vertical retorts; but I am a little diffident just now in saying much about this. At the same time, I feel I ought to say a little. We have had the work in progress for some time; and we have very little difficulty in producing from the Woodall-Duckham retorts a 300 B.Th.U. gas with as low as from 4 to 5 p.ct. CO_2 content. We are using that process on one of our works with a 2,000,000 c.ft. setting; and we are having no trouble whatever. There may be some snags, at first, with regard to it. We found it was necessary to work the water gas retort under level gauge. Very small deviations from level gauge gave trouble, and we had some slight explosions; but I should like to say that at the present time the plant is in the hands of a works foreman, and it is working quite satisfactorily. If there is any difficulty with regard to the gas—it not being possible to see water gas—it is quite possible to put in from 2 to 5 p.ct. of coal with the coke, and you then get a coloured gas which guides the foreman in his work. With regard to the coke itself, if one examines this after it has been through the process, there would seem to be very little variation in the ash content; and the coke is quite useful either for sale or for the producers. The advantage we are gaining from this process is that we do not have to let our retorts down for scurfing. We set-up the water gas reaction in the retort which requires to be scurfed; and in a matter of 24 to 36 hours the retort is quite clear of scurfing, and we get the same output from our setting. This is a very great advantage to us at the present time, because we have found that with some of the foreign coal we have had retorts scurfed-up in very much shorter periods than usual, down to about twelve days—I am speaking of American coal—and we have been able to keep that scurfing down by changing over the retorts to water gas practice. We have four retorts, and only one seal pot; and we found the difficulty was due simply to putting one of the four retorts on to the water gas reaction. We found it advisable to put the whole four on, and work the rest of the setting on coal gas. If we do not, we get variations in the pressure; it is the water gas retort which is liable to give trouble in that respect. That is all I care to say at present. We have not gone so far as to work out the details of the tar enrichment.

Dr. A. PARKER (Leeds): There is nothing, as a matter of fact, in the paper with which I am in disagreement; but since we at Leeds have been working on an experimental scale with different sizes of coal, perhaps I might bring out one or two points of similarity, and also one or two points of difference, in our methods of attacking the problem. The author has found that using the larger grade of coal, as against coal which is ground to pass through a 2 in. screen, he gets a smaller and more friable coke, better steam cracking, a larger yield of tar, a lower gas off-take temperature, and steadier pressures at the bottom of the retort. In our case we used a simple horizontal experimental retort, so the conditions are somewhat different; but, on the other hand, we also found that we got a more friable coke with the larger grades of coal, and a bigger rate of gas production, which corresponds with the author's observations of being able to have a greater throughput in the continuous vertical retort. We also obtained more tar; and these are really the only things which can be compared with the author's experiences. I think the main point that comes out in the paper is the important part played in continuous vertical retort practice, with some steaming, by internal heating. This is very clearly brought out by the fact that a much bigger throughput, with equal efficiency of carbonization from the gas production point of view, or rather better carbonization, was obtained, using large coal which allows the hot gases to pass easily upwards through the retort; and I think that raises a plea for more work on internal heating of charges in vertical retorts. Apparently, with the ground coal in continuous vertical retorts, much of the steam which passes in at the bottom is simply wasted. It lowers the temperature, and presumably travels up the side of the retort without going through the charge of coal, or the coke produced at the bottom. This, I think myself, accounts for the fact that many works operating continuous vertical retorts with steaming are getting such weak liquor—often 4 oz. strength. Much of the steam passed in is not really making water gas, but is simply going forward to dilute the liquor; and this is a very important point.

The author puts forward the suggestion that coals of different coking properties should be blended, or rather mixed, using presumably a fairly large size of coal. This brings us to the point made by many previous investigators about blending—that coals should be blended with one another by powdering, and then mixing. It would appear that if blending and powdering are to be adopted, then, in order to get the free space in the retort for the upward travel of gases, it would be necessary to briquette these mixtures, to produce a condition of affairs which would be equivalent to that of putting large graded coal through the retort. I note (regarding the figures given by Mr. Rhead for the steam passing through the retort in this proposed system of scurfing—by filling the retort with coke, and then passing steam through) from the pounds of steam per hour and the make of water gas, the cracking efficiency of the steam is approximately 45 p.ct. There is one question with regard to that which I should like to ask Mr. Rhead; or possibly Mr. Smith, of Bolton, can answer it. What is the temperature of the gases leaving the top of the retort in which the coke is being subjected to the action of steam? Then there is the question of the moisture in coal. Mr. Rhead has referred to the ordinary method of determining moisture, and quite rightly criticizes the length of time required for even a small average sample of coke or coal. In the Fuel Department at Leeds, it has been the practice for some time to determine in the following manner the moisture content of coals which are wet: A comparatively large sample—say, 10 to 20 lbs.—is taken, weighed out on a tray, and then allowed to stand in a warm atmosphere, at about 90° Fahr., in a steady current of air for, perhaps, 15 to 20 hours, until the surface moisture is evaporated off. Then this large sample is carefully powdered and quartered down to produce a small sample in which the remaining moisture—the inherent moisture—is determined in the ordinary way. With regard to Mr. Rhead's method of leaving a bulk sample at 105° C. for 10 or 12 hours, can he tell us whether he has made any weighings after 4 hours, 6 hours, 8 hours, 10 hours, and then 12 hours? Because it is quite well known that with the ordinary method, if you put a few grammes of coal in an oven at 105° C., the weight at first decreases through the loss of moisture, and then an increase of weight commences owing to the absorption of oxygen. I should like to know whether that has been tested-out, because there may, with many coals, be an absorption of oxygen if left at 105° C. for so long a period as 12 hours. Mr. Rhead must be congratulated on an excellent and suggestive paper.

Mr. W. J. SMITH: As to the question that has been raised concerning temperature, we find there is not much difference in the case of the water gas retort from the ordinary retort. From memory, I think it is about 300° Fahr. at which the gases leave the retort. At the same time, we do find the efficiency of steaming is very much higher than that of general steaming of retorts. Confining it to one retort, it is very much higher; but there is not the same weakening of the liquor as the result.

Dr. E. W. SMITH (London): Mr. Smith, of Bolton, has given a certain amount of information as to the tests that are going on at Bolton; and for your information I think it should be stated that the figure of 300° Fahr. is actually 150° C. I happen to have the figures, and Mr. Smith has not; and I can say that the amount of water gas that is being made regularly, hour by hour, is about 4500 c.ft. of just below 300 B.Th.U. gas. The advantages which we expect to get from running the process can be summarized as: First, the elimination of the time spent in scurfing; secondly, the steam is cracked with about three times the efficiency, and consequently the liquor strengths will be increased; thirdly, the evenness of the heats obtainable through not having to close-down for scurfing should maintain the life of the retorts even longer than now. Of course, during our present troubles there are no testing conditions being maintained; but the process is being worked apparently to Mr. Smith's advantage. To my mind Mr. Rhead's paper is one of the most useful papers that has recently been presented on carbonizing, because it is not merely a paper which gives exact information of the conditions that always obtain, but it is an analysis of conditions that never hold independently. It is an elucidation of some of the factors which considerably affect carbonization—factors which, if we knew a little more about them, would help us to visualize what is going on inside the retort, and assist us in getting over our troubles, at any rate to some extent. A point that needs to be made with regard to the paper, though, is that Mr. Rhead is more or less satisfied that carbonization generally, horizontal and vertical, has approached reasonably satisfactory efficiencies. Birmingham, in the time of Dr. Colman and Dr. Davidson, and now Mr. Rhead, has always tried to be a little bit in front; and they are trying to determine to what extent these efficiencies—I do not want to lay too much stress on efficiencies—can be still further improved. Mr. Rhead has pointed out that the really important matter in carbonization is how to get a lower cost per therm. Therefore, it does not do to stress too much that we want higher thermal efficiencies. It is probably just as important to get higher therms per retort per day as to get higher therms

per ton. It is a combination of these two factors which is supremely important in producing that one factor which matters—viz., the cost of the gas at the retort house. Mr. Rhead states how important it is to note the off-take temperatures, but he also says that it is not an invariable guide to what is happening. It is important to point out, however, that when there is any leakage of air into the gas, then it may be a very important guide—but it is only a guide that there is a leakage. More attention is being given to sensible heating at the present time. I think this is the first time it has been brought out in a definite way, in a carbonization paper, that in vertical retorts, as distinct from horizontals, there is a factor, known as sensible heating, which does not operate to any great extent in static methods of carbonization. This new factor, which may amount, in effect, to 50 p.ct. of the heating in carbonization, needs the specialized attention which Mr. Rhead is giving to these matters. I would like Mr. Rhead to state—this is not the first time I have put this question to him—whether he has come to any conclusions as to whether highly swelling coals really are the cause of sticking in retorts, and whether irregularities in the flow of coals through retorts can be attributed to the swelling properties of these coals. I can imagine that if one has a perfectly smooth retort, and a perfectly even flow line, whether it be parallel or taper, the swelling will primarily be in a downward direction; and I cannot imagine that, except with very irregular or sudden heating, the sticking is due to the swelling of the coal. I am not assuming an abnormal retort or an abnormal coal, but normal coal and normal machinery. In these circumstances I am not sure that the sticking is due to the sudden swelling and a gripping of the retorts. It is more likely that it is due to the irregularity of the charge, and probably over-poking in many cases. Another point I should like to put to Mr. Rhead is in connection with the lack of scurf towards the bottom of the retort. I would suggest that this lack of scurf is not due to the fact that steam is coming into the retort, but is rather due to the fact that by the time the coal has come to that point in the retort, the coke is highly incandescent. There is no gas coming from this part of the coke, so that if there is any scurf formed, it is on the coke itself, and not on the retort walls. I should like to thank Mr. Rhead for his paper, and to congratulate him on the high standard that Birmingham has once more set.

Mr. SAMUEL GLOVER (St. Helens): I have been deeply interested in hearing the paper and discussion as far as it has gone, because it has been proof to me how we have been progressing with regard to the successful working of continuous vertical retorts, and how some of the facilities which this system hands on to you are being developed. It has been of deep interest to me to hear that the experience with internally heated retorts—the system of the production of water gas—is being so successfully developed, and that it is being proved that this system is adding strings to our bow—not only one string, but strings—and enables us to ring the changes on our carbonizing plant so that we can deal with every sort of coal. I therefore thank Mr. Rhead for the work he has been doing. Mr. Rhead has, I feel, been speaking of the heating and working of one type of continuous vertical retort, the experiences with which are not exactly the same as with other systems.

Dr. W. B. DAVIDSON (Newcastle-upon-Tyne): I would like to say a few words on the plasticity of coal, and sticking in retorts. It is unfortunate that vertical retorts should have that little disparagement, though there are no doubt a few highly-coking coals—but very few—which do not work well in vertical retorts. We find this property very objectionable in low-temperature carbonization, and we have found it necessary to classify coals, according to their plasticity, into (say) four different groups. In some kinds of low-temperature plants we have to bar coals which have a high degree of plasticity, because it is no use trying to work with them at all. I do not agree with Dr. Smith about the cause of sticking. I have seen smooth well-tapered retorts made of steel which do not get over this sticking difficulty. It seems that the coal, at a certain temperature, when it is of a swelling nature, melts like pitch, and moulds itself to the sides of the retort, making it almost unworkable. There is, however, a process which seems to be promising, and that is the "thermodizing" process, adopted in America, by Wisner. In that process the coal is previously heated to a temperature of about 300° C. for a long period in a current of air, and this treatment makes the coal much less plastic and far easier to work, and in certain processes gives the highest quality gas. This, of course, may be an awkward thing to work in ordinary retorts, but in other processes it would be a distinct advantage.

The PRESIDENT: I am sure we should like to hear whether the conclusions arrived at by Mr. Rhead coincide with the ideas of others who have had long experience with vertical retorts.

Mr. J. W. MCLUSKY (Glasgow): Some of the things I would have said to-day were printed recently in connection with the Provan installation; but there are two observations I should like to make now with regard to Mr. Rhead's interesting paper. The trouble with the Provan installation has probably been the trouble in other installations; but at Provan the difficulty has been magnified by the size of the installation. After breaking the coal, we have something like 20 p.ct. of very small coal. To get a good throughput, we select coals which will go through the retorts easily. Therefore we have never found at any time the sticking trouble referred to by Dr. Davidson and Dr. Smith. When it comes to the balance-sheet, our trouble is the amount of breeze in the coke, because of this 20 p.ct. of very small non-coking coal. I am glad to know from Mr. Rhead's remarks that Mr. Foster is going to do something which we have been thinking about in Glasgow for the last three years, and which now has been decided upon. At Dawsholm we shall erect bunkers, and make certain that we shall carbonize in these particular vertical retorts coal which is free from this small coal. We shall wash the smalls, and also store specially good coking smalls; and I believe we are going to succeed in making a good coke in a vertical retort. Do not think I am saying we do not make good coke in Provan now. [Laughter.] We do; but we lose money on the amount of the coke breeze. It is all right to be a good scientist and a good carbonizer; but when you happen to be the manager responsible for a good balance-sheet, you have to think of all these things, and we must not let coke breeze spoil a very good job. Therefore, I am going to prophesy that in this 8 million setting at Dawsholm we shall not have the breeze problem in future. The only other observation I wish to make is that I am glad Mr. Rhead has spoken for his own colleagues in the gas industry, the chemists. If there are any town councillors here to-day—I know there are some—I want them always to remember the importance of the purely chemical control of gas undertakings. Supposing a man came to me to-day and said that at the end of the next financial year he would guarantee me two therms more per ton of coal in Glasgow, that man would be worth £40,000 to me. Is not that very important? I have always thought Birmingham in England was like Glasgow in Scotland. We have the same problems, we have this worrying mixture of coal, and we have the problems of a very big area and the multiplication of supervision; and we always feel that if we are following in the wake of Birmingham we are doing well.

Dr. GEOFFREY WEYMAN (Newcastle-on-Tyne): Perhaps many here will go away with the impression that Mr. Rhead's paper is mainly of interest to those concerned with vertical plants; but I do feel that the greater part of it has also practical application in connection with carbonization with horizontal retorts. Those who are not connected with vertical plants will gain much useful information from the paper. As to the temperature control of the gas at the outlet of the retorts, there is only one snag there, and that is connected, I suppose, with having a recording thermometer on every retort. One point upon which I am not altogether in agreement with the author—and I think a great deal more will have to be done in connection with it—is as regards the zoning of the heats throughout the retort to deal with different qualities of coal. My recollection is that when we had that particular difficulty with a swelling coal we were rather inclined to drop the coal into the hottest part of the retort, in order to get over the trouble.

Mr. F. P. TARRATT (Newcastle-on-Tyne): I was rather hoping that Dr. Weyman would make some reference to the carbonization of Durham coal. The idea seems to be prevalent that there is a great difficulty in carbonizing Durham coal in continuous vertical retorts, but I have been doing it for twelve years—first in the 2 million c.ft. plant at Darlington, and more recently in the 5 million c.ft. plant at Newcastle. My conclusions are that Durham coals can be quite well carbonized, provided you comply with certain conditions, one of the most important being that mentioned by Dr. Weyman—viz., the control of the heats. You must have the temperatures right in the various zones, otherwise you will have difficulty. The second point is that reasonable attention must be paid to the rodding. I think the author of the paper suggests that rodding should be carried out once every hour. We could certainly keep Durham coal passing through our retorts if we could get our stokers to rod once an hour. The next thing is the taper of the retort. We have made quite a number of experiments during the last five years to ascertain what the taper of the retort should be; and we have come to the conclusion that a uniform taper for Durham coal gives the most satisfactory results. You then have no difficulty whatever. It will certainly be a long time before we shall entertain the suggestion that we should screen our coal and use the rough coal in the vertical retorts and the fine coal in the horizontals. We have normally a large range of pits to draw upon in Newcastle; and with probably fifteen varieties of coal coming in, we have had a fair amount of experience as to what can be done with carbonizing swelling and non-swelling coals. The three main points to concentrate upon are taper, regularity of attention, and control of temperature.

Mr. W. M. CARR (Stretford): I want to ask a question with regard to the deductions which the author has made on the practical applications, as set forth at the end of the paper. In his preliminary remarks Mr. Rhead stated that from their experience at Birmingham they have found that they make the cheapest gas in the vertical retorts with steaming. In the deductions, however, it is stated that the large coal was to be utilized on the continuous vertical retorts with steaming, and the fine slack, which is of inferior quality and less valuable, was to be used in the horizontal retorts and in the coke ovens. It is difficult to reconcile the two statements; and it would appear from these deductions that Birmingham anticipates that

the cheapest gas will be derived from a combination of continuous vertical retorts and horizontal retorts or ovens. I would like to ask the author if, in arriving at the conclusion which prompted his first statement, he has taken into account the fact that coals which are less valuable on the basis of the cost of coals as bought to-day could be utilized in horizontals, and if the difference in the value of coals was fully allowed for when he claimed that the cheapest gas was made in continuous vertical retorts with steaming. The basic cost of coal in the particular circumstances of any works is a primary factor which often prompts us engineers in the selection of plant for our works; and an increase of five therms in yield of gas may be of small importance when the varying cost of the coal used is taken into account.

Mr. R. G. SHADBOLT: I should like to express my appreciation of the paper which Mr. Rhead has given us this morning—first for the tremendous amount of painstaking thought which it represents, and secondly for the lucid manner in which he has set out the advantages of studying the effect of sizing or grading coal. My thoughts run on the lines of the advice of old Thomas Newbigging years ago, when he exhorted the young men of the gas industry to put their brains into the retorts—not for carbonizing purposes, as he added, but for purposes of investigation. I wonder what his comment would have been had he been present at the meeting yesterday and to-day, and had seen the way in which the young men of the industry to-day are literally carrying out his exhortations. I think it is a mark of the great progress that is being made. The principles which are being elucidated will, in the near future, I feel certain, bear great fruit not only as regards continuous vertical retorts, but as regards carbonization and gas making generally. We have yet a long way to go; but the paper marks, in a practical way (as distinct from the laboratory, but corroborated by the laboratory), the distinct increase in our knowledge of what is going on and what is required in the treatment of the coal which we convert into our main commodity. I was struck with the remark of Mr. Samuel Glover, who spoke of these things as adding strings—plural, mark you—more strings to our bows. This reminded me of the time when I bought a pony for my wife and children. It is all very well with one pony; but when you have got a pair of ponies, and four strings or reins in your hands, it is a little bit more difficult. When you have to drive a team of four, you find that some of them are turning round and looking back at you. I begin to wonder what will happen when we get too many strings to our bows. I mention this merely to bring out the fact which has been evident to myself and many others for some time, and that is that it is useless—absolutely useless—piling up capital in the installation of vertical retorts, with all their refinements and their effectiveness, unless we are prepared to subject them to the greatest amount of care and skill—technical and otherwise—in their working and in their handling. You want an expert driver; you want constant attention and the best supervision, otherwise they will prove in some cases—I have known them to be—white elephants. There are other systems of carbonization; and our knowledge of the principles underlying them all has been so increased by papers such as the one we have had this morning that I could not do other than to express my appreciation of it.

The PRESIDENT: Unless there are any other speakers, I will close the discussion. For my own part, I have little to say. I would ask the author, however, if the jointing in the vertical retorts has anything to do with the problem of adhesion or sticking. A point which appeals to me from another aspect is the flexibility which is now being given to the vertical system, making it comparable with the extraordinary flexibility that exists in the combination of horizontal retorts with carburetted water gas plant. It is appreciated that the experiment which is being carried out at Bolton, due, I believe, to Dr. E. W. Smith, and referred to in Mr. Rhead's paper, will be of the greatest possible assistance in helping us to improve this flexibility. It must be of advantage, if it is successful, with regard to scurfing. Though it is not strictly within the purview of the paper, I feel that I am justified in calling attention to the great advantage which accrues to the industry to-day from the existence, from one end of the country to the other, of plants which enable us to use coke for the production of gas, supplementary to coal gas manufacture.

Mr. RHEAD, replying to the discussion, said: The discussion has been extremely gratifying in the number of people who have spoken, and also because I think many of the questions have been answered during the discussion. As previously mentioned, coal A comes from the Nottinghamshire district, and coal B from the South Yorkshire district. I was extremely interested in Mr. Smith's account of the Bolton work, and also Dr. Smith's amplification of it. I agree it is important to watch the pressure in the top of the retort; it is essential to keep it at level gauge. You want neither to draw in air or furnace gases nor drive out the CO. I am interested to hear you can scurf the retorts in from 24 to 36 hours. This strikes me as much shorter than I had expected. I think many of us have been having trouble with some of the extremely rich American coals. Dr. Parker mentioned the small percentage of steam which is cracked in verticals. This, of course, depends on the amount of steam put in, but it undoubtedly has caused us trouble in Birmingham by weakening the liquor; and anything which will help us to get a better steam cracking efficiency will be an undoubted advantage. I was interested in Dr. Parker's account of determining moistures in coals. A point which we have considered is whether it will be worth while passing CO_2 from cylinders through the oven where we are drying the coal, to prevent oxidation. I do not call to mind any weighing after drying only four hours, but we frequently have determined the drying time necessary to give a constant weight. Undoubtedly there is a certain amount of absorption of oxygen; and with one or two coals at the temperature I have mentioned we have even had them take fire. This, of course, is nothing new to people engaged in the mining industry. I think I mentioned at the outset of my paper that I appreciate that verticals and horizontals, and other carbonizing systems, have reached very high efficiencies, but that by studying the working details more we can hope to improve these efficiencies further. The offtake temperature, as Dr. Smith remarks, is not an infallible guide. You get combustion of hot crude gases if you have in-leakage of air through top ironwork, which gives a high offtake gas temperature, and which is not a true reflection of the working of the retort proper. There is another point. If you have excessive moisture in your coals, as, for instance, on a wet day, before they are elevated, you get an abnormally low temperature, and that again masks the true effect of the working of the retort. I think it was Dr. Weyman who mentioned that it would be impracticable to have a thermograph on each retort. Of course, nobody would reasonably suggest this, with the present price of thermographs. But I do suggest that it is desirable that engineers should have a reliable thermograph in their office; and if they think any retort is giving trouble, they can take a record, and see what is happening.

Dr. Smith also raised the point as to whether the swelling of coal is the intrinsic cause of sticking. We are all familiar with the fact that various adhesives stick to various surfaces with different tenacities, and personally I think there is a lot in the actual nature of the semi-fluid coal and the surface to which it is adhering. The smoothness of the surface, of course, does come in considerably. Then, again, sticking is bound up with the plastic range. Some coals have a wide plastic range, and others a low one. The rodding of retorts, I have always felt, is a crude way of helping the charge down the retort. It is very important that your rods should not be wedge-shaped at the bottom. You want to have them rather wide and flat at the bottom, so that you get a real rodding effect. If you have the rods wedge-shaped or pointed, you wedge the charge, and you may make matters worse instead of helping them. Undoubtedly a great deal depends upon the personal element in rodding; some men are good, and some are very poor. The question of lack of scurf at the bottom has been mentioned. Of course, you would not expect to get scurf in those zones where you have no degradation of hydrocarbons taking place. When we were carbonizing without steaming in verticals, the scurf extended considerably lower down the retort than now, and personally I think the reduction of scurf is undoubtedly due to the effect of the steam. I was interested to hear Mr. Samuel Glover's remarks on water gas production in verticals. It certainly gives greater flexibility to a system which is already extremely flexible.

Dr. Davidson's remarks on plasticity were very useful, and I think Mr. Tarratt has answered Dr. Davidson's question as to the possibilities of working Durham coals. I am well aware that Durham coals can be worked satisfactorily in verticals. The separate process of preheating coals for verticals to 300° C. to reduce the swelling properties does not attract one very much, because it means multiplying plant, &c. The troubles of Mr. McLusky, of Glasgow, are apparently due to non-coking coals, not sticking coals. He is working, I take it, with Scotch coals, which are well known to work very easily in vertical retorts; but I expect one gets an excessive amount of dust in the coal when dealing with small fine Scotch coal. I am glad he emphasized the need for chemical control.

Dr. Weyman raised the point of zoning heats. I appreciate that there is a lot more to be done on this question. Personally I have only touched the fringe of it. What is possible in experimental work depends on the particular method of heat control. For example, I have rather envied Dr. Lander's research plant at East Greenwich, where he can get much greater refinement in heating than is at present economically practicable from a commercial point of view. You can only get such research refinements by sending streams of fuel gas, and secondary air for combustion, through separate burners and control cocks. Dr. Parker is doing the same thing on his research plant. Mr. Tarratt made some valuable remarks on the necessary conditions for working Durham coals. The control of heats, of course, is a very important point. I agree that there should be regular and intelligent rodding and suitable taper of the retorts; and there is no doubt room for much more experimental work. The various manufacturers of vertical retorts are doing a large amount of experimenting in this particular line.

Mr. Carr has raised the point as to whether, when I said that Birmingham is making cheaper gas on verticals, I have taken into account the fact of the fines being carbonized on horizontals, and that this affects the price of the coal to be used in the two systems. I have taken that into account. The amount of

fines we are able to carbonize by horizontals is a very small proportion of our yearly tonnage, because it is only on one works and during the heavy winter load that we have these particular horizontals working. Then, of course, another point I have specially mentioned in my conclusions is that it is only where you have already in existence horizontals or ovens that separating the fines for the horizontals is a useful thing to do. Naturally, if you are building a new works, you would go into the question of capital and working costs, as well as the question of ease of working; and very likely you would find it would not pay you to put in both systems. It might pay you to put up with any troubles you might have with some sticky coals on the verticals, rather than put in two systems. Again with regard to Mr. Carr's remarks, in Birmingham our latitude for exercising selection of coal is somewhat limited, because we have to buy such a large annual quantity, and therefore we are not able to confine ourselves to a few particular kinds of coal.

I must thank Mr. Shadbolt for his kind remarks, and I think with him that it is a useful thing to urge, metaphorically of course, that we should put our brains into the retort. As to the President's remark with regard to jointing, and its possible relation to sticking, I suppose he means whether the roughness due to the joints coming out causes trouble. When starting up a retort after scurfing, if the retort wall is rough you are likely to have more trouble with sticking if you have a sticky coal. However, the retort wall in the zone where stickiness occurs soon gets coated over with a layer of scurf, and you know that after you have had trouble with it for a few days, the retort may then work sweetly.

Mr. W. J. SMITH (Bolton): May I correct a mistake that I made when I spoke early in the discussion? Mr. Rhead called attention to the low time of scurfing which I mentioned—viz., 24 to 36 hours. I should have said two to three days. I am not surprised that Mr. Rhead was astonished.

REPORT OF THE REFRACTORY MATERIALS JOINT COMMITTEE.

The Joint Committee consists of Messrs. John P. Leather (Chairman), J. W. Mellor, D.Sc. (Director of Research), J. Ferguson Bell, J.P., John W. Cobb, B.Sc., Harold G. Colman, D.Sc., Thomas Hardie, Percy N. Langford, H. D. Madden, W. E. Price, T. F. E. Rhead, M.Sc., E. W. Smith, D.Sc., Samuel Tagg, J.P., John Wilkinson, O.B.E., representing the Institution; and Messrs. T. Allen, M. Barrett, F. H. Brooke, Albert Cliff, G. V. Evers, J. W. Fagan, W. T. Gardner, G. H. Pearson-Perry, and Frank West, representing the Society of British Gas Industries.

In reporting the work of the Committee last year, reference was made to alterations which had been made in the Standard Specification for Refractory Materials for Gas-Works. Several clauses in this specification have again claimed attention. The increased use of higher temperatures of carbonization necessitates careful selection of refractory materials. The standard test for contraction and expansion is carried out at a temperature of 1410° C., while in some cases, particularly in the neighbourhood of the zone of combustion, bricks are regularly exposed to a higher temperature. It has been recognized for some time that, in the case of silica goods to be used at high temperatures, considerable importance attaches to the extent to which the silica has been converted into cristobalite and tridymite, and as an indication of this a test of the "true specific gravity" is frequently made.

It has been suggested to introduce this test into the Standard Specification. Before making any alteration in this direction, or in the test for contraction and expansion, information on tests which have been made on materials in use is being collected from various sources, to enable a balanced judgment to be made. By permission of the Committee of the Privy Council for Scientific and Industrial Research, we are able to present nine of the papers which have been prepared during the past year recording the results of researches of the British Refractories Research Association.*

A communication by A. J. Dale, detailing an investigation of a premature failure of combustion chamber material, illustrates the value of the work on which he has been engaged for some time, reports of which appeared in the "Transactions" of 1924 and 1925. Further work by him on the effects of temperature on the mechanical properties of silica products and the control of silica brick-making has not only an important bearing on the control of the conditions of manufacture, but emphasizes the need of choosing a brick with reference to the conditions of its use.

The depreciation of brickwork consequent on the action of molten coke ash, particularly in the zone where there is direct contact between the fuel and furnace lining, constitutes a most difficult problem. Mr. A. J. Dale contributes a résumé of the present state of experience in testing material to resist this action.

Mr. A. E. J. Vickers gives the results of further experiments on the influence of oxidizing and reducing atmospheres. In these the powerful reducing action of water vapour is again notable.

Mr. A. T. Green reports his further work on the temperature diffusivity and thermal conductivity of refractory materials at high temperatures, and also a special investigation on the conductivity of a semi-silica material after use in a coke-oven wall compared with its conductivity before use.

The difficult question of the spalling of silica material at low temperatures is the subject of an investigation reported by Green and Edwards.

A considerable amount of other work is in progress, and promises interesting and useful results. The funds at the disposal of the British Refractories Research Association are not sufficient to carry on all the work which ought to be undertaken. Efforts are being made to enlist greater support from other industries in order that the requirements of the Department of Scientific and Industrial Research may be met.

*(A) "An Investigation of the Premature Failure of Combustion Chamber Material." By A. J. Dale, B.Sc., A.I.C.

(B) "The Effects of Temperature on the Mechanical Properties of Silica Products." By A. J. Dale, B.Sc., A.I.C.

(C) "The Control of Silica Brick Making, Based on Load-Test Indications," Parts I., II., III., and IV. By A. J. Dale, B.Sc., A.I.C.

(D) "The Testing of Refractory Material for Resistance to Slag Corrosion and Erosion." By A. J. Dale, B.Sc., A.I.C.

(E) "The Influence of Oxidizing and Reducing Atmospheres on Refractory Materials," Part II. By A. E. J. Vickers, B.Sc., A.I.C.

(F) "The Temperature Diffusivity and Thermal Conductivity of Silica Refractory Material at High Temp ratures." By A. T. Green, A.Inst.P.

(G) "A Comparison of the Temperature Diffusivities and Thermal Conductivities of Silica and Fireclay Refractories." By A. T. Green, A.Inst.P.

(H) "The Effect of Industrial Usage on the Thermal Conductivity of a Semi-silica Material used in a Coke-Oven Wall." By A. T. Green, A.Inst.P.

(I) "The Spalling of Silica Refractory Material at Low Temperatures." By A. T. Green, A.Inst.P., and H. Edwards.

(A)

AN INVESTIGATION OF THE PREMATURE FAILURE OF COMBUSTION CHAMBER MATERIAL.

By A. J. DALE, B.Sc., A.I.C.

Several previous "Bulletin" communications have reported the progressive development of the original scheme of work on the high-temperature load test for refractory materials; and on the various factors influencing the behaviour of firebricks under stress at high temperatures. A consideration of the collected data has suggested that the substance-temperature curves obtained under two different loadings, one high and one low, can prove an exceptionally fruitful source of information. This information applies particularly to the degree of cohesion existing in firebrick products at high temperatures between the matrix particles themselves or between the matrix and the grog, during the initial life of a brick in certain industrial settings; and also to the viscosity-temperature relations of an important fraction of the supporting structure of a brick.

In order to make clear the method of interpreting a modified Mellor and Moore load-test result to those who may, as yet, be unaccustomed to this test, it seems desirable, as opportunity arises, to examine, by means of the modified load test, materials which actual practical experience has shown to be either exceptionally faulty or exceptionally good under a given set of service conditions.

The results from this procedure may not only inspire a greater degree of confidence in the modified load test, but should also suggest definite characteristics which ought, or ought not, to be possessed by a refractory intended for a definite purpose.

The present paper accordingly presents the results of

FIG. 1.

an examination of a siliceous material which failed prematurely in the combustion chamber of a gas-retort setting.

THE MATERIAL.*

The material of this investigation is one which has been in demand for retort house work on account of certain peculiar physical properties. Previously tested samples have shown an ordinary refractory test result of Cone 29, but the representative sample forwarded for this work gave an ordinary refractory test result of Cone 19. The chemical composition and certain physical data are tabulated below :

Ultimate Chemical Composition.

SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	Loss.
88·12	0·17	4·60	2·65	1·18	0·36	1·04	1·10	0·76

Physical Data.

True Sp. Gr.	App. Sp. Gr.	True P.Ct. Porosity.	App. P.Ct. Porosity.
2·635	1 662	36·9	36·9

Comparing the true specific gravity of 2·64 with the silica content of 88 p.ct., it seems that the material contains a large amount of unconverted quartz, and it might also be inferred that the original kiln firing was decidedly moderate. The porosity seems very high; and the agreement between the true and apparent porosities shows the pores to be entirely of the "open" type.

DESCRIPTION OF THE FAILURE.

According to the user, the accompanying photograph (fig. 1), illustrates "the collapse of the arches, which occurred immediately the bed was brought up to working temperatures, which certainly did not exceed 1300°." This statement does not necessarily imply that the brick face temperatures in the combustion chamber itself were limited to 1300°; the temperatures there would presumably reach 1500° or more where direct impact occurred between flames and the masonry.

CONSIDERATION OF THE FAILURE.

A detailed examination of the photograph shows that failure occurred at three fairly well defined zones.

(1) A zone (B, fig. 1) situated well back from the inner periphery of the chamber.
(2) Another zone (A, fig. 1) about one-third the length of the brick nearer the inner face.
(3) Localized zones of overheating actually on the inner face, and apparently marking the points of direct flame impact (C, fig. 1).

From the clear-cut appearance of the ruptures and cracks at A and B, it appears likely that failure at these zones is due rather to *mechanical weakness* than to the *viscous flow* which has obviously taken place at the zones, C.

RESULTS OF THE LOAD TEST EXAMINATION OF THE MATERIAL.

The result of the modified load tests carried out on the unused brick samples are recorded graphically in fig. 2. The ascending portions record the thermal expansion under load of the test pieces, together with that of the carborundum thrust-rod and basal supports. However, since the carborundum material used in the test-furnace shows an almost linear expansion under these loads and up to the maximum temperatures reached in these tests, any *marked* deviations from the linear are caused by expansion peculiarities of the test material itself.

Curves 1 and 2 on the diagram, fig. 2, show the expansion—and subsidence—temperature curves obtained under loadings of 50 lbs. and 10 lbs. per sq. in. respectively. These two loads have been provisionally proposed for standardization purposes, but the close similarity of the two results suggested that, in this case, a further test under a still lower load was required for a more complete solution of the problem. Curve 3, fig. 2, shows the result of this third test under a load of 4 lbs. per sq. in.

Considered along with the ordinary refractory test result of Cone 19, the sub-diagram of fig. 2 emphasizes the sensitivity of the material to low stresses.

FACTS ESTABLISHED BY THE MODIFIED MELLOR AND MOORE LOAD-TEST RESULTS.

A joint consideration of the three curves indicates the following facts :—

(1) The temperature at which *rapid failure* develops under a 50 lbs. per sq. in. loading (*circa* 1130°) is exceptionally low; furthermore, each curve exhibits a *flattening* at a brick face temperature of 1000° to 1025°.
(2) The difference between the behaviour of the test material under a 50 lbs. per sq. in. loading and under a load of 10 lbs. per sq. in. is hardly appreciable.
(3) While a lowering of the load from 50 to 10 lbs. per sq. in. has very little effect on the subsidence-temperature curve, a comparatively enormous effect results from a further lowering of the load by only 6 lbs. per sq. in. (*i.e.*, under a load of 4 lbs. per sq. in.).
(4) The 4 lbs. per sq. in. curve records a local expansion between 550° and 600°, probably due to an $\alpha\ \beta$ quartz inversion at 575°; but no signs of a corresponding expansion are reproduced in the vertical expansions recorded under the higher loadings.
(5) An examination of the test-pieces after testing showed that the 50 and 10 lbs. tests had failed mainly by shearing with little softening, but that the converse was true in the case of the 4 lbs. test.
(6) A noticeable deceleration in the rate of subsidence at around 1200° C. and under the load of 4 lbs. per sq. in.

SUGGESTED EXPLANATION OF THE FACTS.

(1) Since the *flattening* of the expansion-under-load curves around 1000° is evinced under the lowest load as well as under the highest, it appears to be caused mainly by a premature softening of, at least, an im-

* I am indebted to Dr. Mellor and to the North Middlesex Gas Company for photographic and other details in connection with the experimental material.

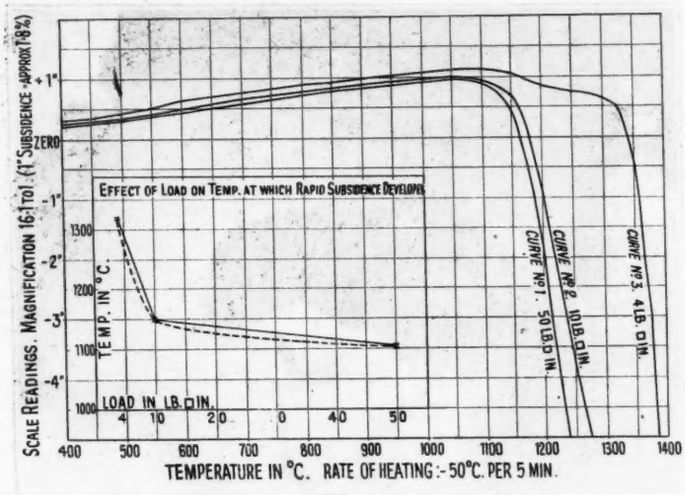


FIG. 2.

(For clearness, the origins of these curves are separated by $\frac{1}{10}$ in.).

portant evenly-distributed portion of the brick matrix or bond.

(2) When the load is sufficiently high (50 or 10 lbs. per sq. in.) to cause fairly rapid deformation while the bond is in this semi-fluid state (1000° to 1100°), *either* (*a*) the bond is unable to adjust itself to the continual movement, loses its grip on the siliceous grains, and the brick collapses; or (*b*) the fluid fraction is rapidly displaced into the pore spaces and the less mobile portion of the supporting structure of the brick is unable to withstand the additional load which is suddenly thrown upon it.

Either explanation fits in with the observation that actual separation of the test pieces occurred along the diagonal plane of greatest shear.

(3) At brick face temperatures between 1150° and 1320° approx. a stress between 4 and 10 lbs. per sq. in. in magnitude is sufficient to cause deformation with rupture under the test conditions, in addition to the normal viscous type of subsidence.

(4) An uncertain amount of disrupture occurs under loads of 10 lbs. per sq. in., or more, as the temperature of the test piece passes the α β quartz inversion temperature, 575°. The matrix appears to be able to withstand the "inversion stress" developed at this temperature *plus* an additional stress of 4 lbs. per sq. in.; it is unable, however, to maintain a vertical thermal expansion against the disruptive effect of the "inversion stress" *plus* 10 lbs. per sq. in. or more; hence the above conclusion.

(5) The decelerating rate of subsidence between 1200° and 1300° in the 4 lb. test suggests an internal expansion and stress development caused by the incipient conversion of quartz (density 2·65) to cristobalite (density 2·33). This internal stress is probably responsible for the signs of mechanical disrupture (as compared with viscous squatting) noticed on the piece after testing.

Application of the Laboratory Indications to Actual Behaviour in Practice.

We can now apply these considerations to practical conditions—to the combustion chamber constructed with this material. Providing the rate of rise of temperature of the brickwork is gradual and carefully regulated during the initial period of use, the temperature of the tapered arch sections may progressively pass the danger temperatures (575° and *circa* 1100°) without the rapid development of thermal stresses sufficient to cause loss of cohesion and rupture.

Moreover, at temperatures prevailing during normal use of the chamber, the bonding of the exposed and adjoining parts might conceivably be improved during use. Unsatisfactory expansion facilities at the periphery of the chamber coupled with unexpected or uncontrollable temperature fluctuations at the interior face will then bring into being stresses which, as the load tests proved, will exert a maximum deteriorating effect at these two sensitive temperatures (*circa* 1100° and 575°). The clear-cut appearance of the fractures at the zones A and B, fig. 1, suggests failure here to be due to mechanical weakness, before much softening had occurred. The inference therefore appears to be that the stress development due to restricted thermal expansion during heating up has been either too great or too rapidly developed. In the former eventuality design and material are probably at fault; if the latter explanation holds, undue haste during slow fire and final heating is responsible for the premature failure.

Uneven temperature distribution and uneven stress distribution, such as will obtain in an arch of elliptical section, explain why the rupture zones are not continuous or symmetrically disposed.

The softening squat at comparatively low temperatures in the 4 lb. test explains the "running" at points C (fig. 1), where local overheating due to direct flame impact has obviously occurred. It is interesting to note, at one of the points C, how this "running" has linked up with the first rupture zone, corresponding to A at this point, causing a falling away under its own weight, of a considerable amount of brickwork.

Although comparatively low refractoriness, as judged by the ordinary refractory test or by a low-load test, need not necessarily preclude the use of a given refractory for combustion chamber work, low refractoriness coupled with mechanical weakness near but below working temperatures would seem to be a most undesirable combination of physical properties for this specific purpose; also, there seems no reason why this criterion should not apply equally well to high-temperature arch-constructional material in general.

Conclusions.

It is suggested that fine-grained, friable material with a silica content in the region of 88 p.ct., *and containing considerable free quartz,* needs special care during preliminary heating up; particularly if the iron and alkali contents of the brick are high and if the colour suggests a homogeneous distribution of the iron compounds.

If laboratory-examination by means of modified Mellor and Moore load tests indicates only moderate refractoriness, and mechanical weakness near working temperatures, constructional details—arch design, suitable expansion arrangement, the use of a contractile mortar, &c.—would seem to merit special attention. From the maker's view-point, the high-temperature mechanical weakness might be minimized, or transferred to a still higher temperature, by small additions of a plastic vitrifiable bond clay, and a corresponding modification of the kiln firing. At the same time, this procedure may mean sacrificing certain desirable characteristics of the fired product.

In conclusion, this work has indicated that combustion chamber material should satisfy two criteria:—(*a*) Moderate or high refractoriness; (*b*) good cohesion be-

tween grog and matrix up to maximum working temperatures. A proper interpretation of two Mellor and Moore load tests (high and low loadings) will evaluate, qualitatively, the degree to which these desirable characteristics are possessed by any given product.

[*Communications B to I inclusive will be reprinted in extenso or in abstract as occasion offers in future issues of the* "JOURNAL." *Meantime, a brief reference is made to them in our Review of the Proceedings.*—*see p.* 766.]

Mr. J. P. LEATHER, presenting the report, said: I have pleasure in presenting the Report of the Refractory Materials Joint Committee. You are aware that the research work on refractories is carried out through the British Refractories Research Association, which, in common with other industrial research associations, was founded in connection with the Department of Scientific and Industrial Research. The Association is labouring under difficulties at the moment. On the one hand, the Department is seeking to withdraw the grant of pound for pound subscription; and on the other hand the depressed state of the industries using refractories, especially the iron and steel industries, is rendering it difficult to maintain subscriptions to the Association. Therefore, the Association has been compelled to reduce its estimates of the programme of work during the ensuing year. All this is not really part of the report; but I thought it was right that I should mention it now, because the problem of how we are to continue research work which has been conducted for some years is important.

We have, however, in the report which is presented to-day, a considerable volume of work of interest to the gas industry. This report was really prepared for the June meeting; and the papers A, B, C and J—I am taking them out of order—deal with the effects of temperature on silica bricks either in manufacture or in use. The first paper is by Mr. Dale, and details an investigation of the premature failure of combustion chamber material, and illustrates valuable work which has been done for some years, and has appeared in the Transactions for 1924 and 1925. Further work by Mr. Dale on the effects of temperature on the mechanical properties of silica products and the control of silica brick making, which appears in papers B and C, not only has an important bearing on the conditions of manufacture, but emphasizes the need for choosing a brick with reference to the conditions of its use.

It was interesting to hear yesterday the remarks of Mr. Carr as to the use of silica material; and a careful study of these four papers in the report to which I have referred emphasizes the fact that in the use of silica refractories we are dealing with a material having very complicated properties. This is due to the fact that silica exists in three distinct modifications—viz., quartz, cristobalite, and tridymite. In the case of quartz, this exists in two forms, the alpha and the beta. Cristobalite also exists in two forms, and tridymite in three, making seven different modifications of silica, each of which has a different density and therefore a different volume; and as the silica changes from one form to another at certain more or less definite temperatures, it is necessary to exercise considerable care in the use of silica materials. It has been thought that it was necessary—in fact, it is necessary—that in silica materials used at high temperatures the quartz in the original material should be transformed in the process of manufacture into either cristobalite or tridymite; but this does not get over all the difficulties, because of this inversion of these forms of silica at low temperatures. The change from one form to another, involving a change in volume, tends to produce spalling; and it is by investigating this condition that we see what is the underlying cause of spalling which occurs in silica bricks, and the reason why we should be very careful in the heating-up of the material. We also see in what way we can overcome it. It is partly through the careful heating of the brick, and partly through the manufacture of the brick in such a way that it will have sufficient elasticity to stand the changes of temperature. These papers which deal with this matter are all well worth study.

I would like to mention the other papers, D and E, by Mr. Dale and Mr. Vickers, which deal with the important questions of the effect of slag and molten coke ash and of reducing atmospheres, again pointing to the great effect of water vapour in reducing the iron content of bricks, and consequently tending to depreciate the material. These particular papers, though they are important, are, after all, somewhat preliminary. We have not yet solved the difficulty of how to produce a material which will withstand the corrosive action of slag, nor do we thoroughly understand how to approach the question; but we are leading on towards it, and further work will probably give us much more useful results. Then we have two papers on thermal conductivity, by Mr. Green, who has also prepared the final paper on spalling. Paper H shows the effect of use on the conductivity of a siliceous material employed in a coke oven wall, and demonstrates that there is an actual increase in conductivity in consequence of the change that takes place in the brick during its use. Paper G is particularly interesting in view of the statement frequently made respecting the superior conductivity of silica materials, and which was referred to in the discussion yesterday. It will be seen, when these papers are studied, that there is very considerable variation in the conductivity of different silica bricks and also of different fireclay bricks. Taking a temperature under 1000° C., the difference between fireclay and silica is not very striking; but at the higher temperatures silica certainly has the advantage in conductivity. Some firebricks, however, showed a higher conductivity than some of the silica bricks. I think this is to be borne in mind when we hear the statement (which was made, for instance, yesterday) of a considerable increase in the value of a silica retort as compared with a fireclay retort in the amount of gas that can be produced.

I have taken the actual research work first, but in the report, as printed, we discuss first the question of the specification; and here we are really dealing not with the work of the British Refractories Research Association directly, but with the work of our own Committee, which operates, of course, jointly with the Committee of the Society of British Gas Industries. Last year in the report reference was made to several clauses in the specification which had been altered. We are still discussing these clauses, and there has been some difficulty in reconciling the different opinions of the two branches of the Committee. One of the particular points which we are still discussing is the standard test for contraction and expansion, which is at present carried out at a temperature of 1410° C. In many cases nowadays, however, silica bricks, particularly in combustion chambers, are exposed in actual practice to higher temperatures than this; and it becomes, therefore, a question whether the standard test ought not to be conducted at a higher temperature, as some firms do, and as, I believe, Mr. Rhead, of Birmingham, regularly does.

Then there is the other point to which I have already referred in connection with the papers—viz., the question of the specific gravity of silica goods. The desirability that all the quartz in silica goods should be converted into other forms of silica has caused a number of users to specify that silica goods should have not more than a maximum specific gravity, to ensure that they do not have unconverted quartz, but other modifications of silica. We published in connection with the standard specification a standard method of determining the specific gravity; but we have not included it as part of the specification, because we are still hardly sufficiently far advanced in our knowledge, and, more than this, the gravity of the silica is not everything. There are so many other factors, and the whole question is so complicated—particularly in this way, that it might be that a brick which was very good for standing very high temperatures under certain conditions was perhaps not so good when used under other conditions. For instance, if there is a variation of temperature in use, then there may be variations in specific gravity, and consequently in volume, through the inversion of the silica. Silica working at a certain temperature may be in one form, and in another form at a different temperature. It may change from the alpha to the beta modification. If that is so, then we want to exercise great care in using a brick of cristobalite at about the temperature at which inversion takes place.

All that I have been pointing out is the great importance of studying with the utmost possible care the exact way in which silica goods are to be used, in order that we may be able to choose the best materials. I do not suppose that at this meeting there will be any discussions on the papers which are included in the report, but I have great pleasure in presenting the report, and I believe that it will be of considerable value to those who study it.

Discussion.

The PRESIDENT: This subject is of vital importance to us, especially as we keep raising our temperatures of carbonization; and I am sure we are greatly indebted to Mr. Leather for the persistent care and enthusiasm with which he has tackled this subject. It may not appeal to all our members; but I can assure you that they are really affected by it, whether they recognize it or not. It is a matter of vital interest to us all. There is just time for a few observations on this report, which is really a compilation of papers presented by skilled workers in this particular subject.

Mr. THOMAS GLOVER (Norwich): I should like to thank Mr. Leather and the Committee for their patient and persevering work. They are engaged on research work which is of great importance to the whole industry. We have recognized this for some years; and though there is such a small attendance at this hour (due, I think, to the temperature of the room), we hope the Committee will continue their work. One remark of Mr. Leather attracted my attention. He emphasized the importance of bricks being chosen for the particular duty they have to perform. I think we are all recognizing this more and more. We recently put in a vital place in a water gas generator four different qualities of brick. One was rich in sillimanite—*i.e.*, the alumina quality—but it disappeared, and a pure silica brick did not stand up very well. A brick of a tough texture containing a moderate percentage of

silica stood up best; and that rough test will be a good guide to us as to which is the best material in that particular part of the water gas generator. Other important experimental work needs to be done, so far as I have been able to judge from this brief résumé of the report. I do not think there has been considered the effect of the steaming process inside vertical retorts, and the conditions which exist inside the retorts at different tiers. Different actions are going on right through the retort; and there is a sort of erosion, a rapid wearing away, at the place where the water gas reaction occurs. With some materials this happens to a serious extent, whereas with others we find this erosion less serious. With careful selection, it appears we can get vertical retorts to stand five years' work. The worst worn parts can be cut out and replaced without taking out the setting, which is a tremendous saving in expense. However, the erosion which takes place at the water gas zone is worthy of the attention of the Committee. I hope the Committee will be successful in adding to our knowledge on this subject. I will move the acceptance of the report, and that we give our best thanks to the Committee and their Chairman for their patient and persevering work.

Mr. G. M. GILL (London): There can be no question that this report will be of great value in certain quarters. No doubt it will be of more direct value to the manufacturers than it is to the users of refractory materials. But the gas industry gets the benefit of this indirectly. Refractory materials are improving, and steady progress is being made. I would, however, plead that in the Refractory Materials Committee's Report there should be at least one practical paper dealing with the problems that gas engineers have to solve and contend with in their regular work. I am a member of the Ceramic Society, and I usually attend the Refractory Materials Section conferences. At the last conference at Leeds there was a splendid practical paper entitled "Refractories in the Gas Industry," by Mr. W. T. Gardner, of the Woodall-Duckham Company. In that paper are the points gas engineers want to know about. Mr. Gardner has done this work for years; and I listened to that paper with the greatest possible interest. I only mention that as being the type of paper I should like to see included in the report of our own Committee each year.

The next point is that there is no doubt that a strong case can be made out for an amended specification. If I may say so, the specification seems to me—and I know to many others—to be getting out of date. For instance, the refractoriness of refractory materials, to a practical man, can be a snare and a delusion. The refractoriness of fireclay may be shown to be very high, but its refractoriness under load, in the condition it is in a retort setting, may be some 300° C. lower; and while we may think we are buying some good stuff, it will soon fail. I know that I once built retort settings of refractory material which was very refractory, and had done excellent work in gas furnaces where very high temperatures were used. I built a setting of that material, and the whole setting collapsed in a few months. If an under-load test had been applied to that material, it would have shown its defective qualities at once. Our specification should contain an under-load test. The test of refractory materials under load is becoming more and more used, and is one which practical gas engineers want. Refractoriness by itself, to my mind, is no good whatever.

The next point in the specification is the after-expansion of silica. You have not to worry about the under-load test itself with silica, because this material will stand very high temperatures under load. The thing one has to worry about most of all is its after-expansion. In the specification the test specifies a temperature of 1410° C. as the temperature to which the material should be subjected for two hours; but many people are using higher temperatures than this. In America 1450° C. is the average combustion chamber temperature, and it is so in many works in this country. Therefore, what is the good of testing material at a lower temperature? For the purpose of retort settings, I think we ought to make the after-expansion test at least 1500° C.

One other matter. You have a specification, and you buy materials to be supplied to that specification. You can take your samples when the material is delivered at your works, but it is a great pity and a distinct disadvantage if you have to reject it at that time. It would be much better if the material could be sampled at the manufacturers' works. With the smaller undertakings, this would be a difficult and expensive thing to do; but is it not possible that some organized system of inspection and sampling could be devised, especially for the smaller undertakings? When I was with the South Metropolitan Gas Company, we arranged for an inspector to be always at the manufacturers' works. This was his sole job; and I am sure it resulted in our obtaining good material. I should not like my remarks to be taken as critical of the report, because I think it covers most useful ground, and I attach great importance to the research work that is being done. I am asking for an extension of it, in the direction of a practical paper, and also for an amendment of the specification.

Mr. F. P. TARRATT (Newcastle-upon-Tyne): I should like to ask one question. There are nine different papers presented in the report. Is it a fact that the bulk of these papers have been published before by other technical societies, or is this their first issue?

Mr. LEATHER: They are not published by societies other than the Refractories Research Association, who only publish these papers as confidential documents to their members. We are not allowed to circulate them without the consent of the Department of Scientific and Industrial Research; and we had to obtain this consent in this case.

Mr. TARRATT: Mr. Leather has referred to the fact that the funds of the Research Association are being curtailed. Cannot the Refractory Materials Joint Committee consider whether they are justified in the expense involved in printing and publishing nine papers representing 147 pages of matter in the report? The actual report of the Committee covers only 2½ pages. I would like to support Mr. Gill in asking for something practical. There are scores of engineers who will never have time to read this report as a whole; and I feel that the Refractories Research Association are getting into this difficulty deeper and deeper every year. Therefore I ask whether we are justified in publishing all these papers, especially in view of the fact that they can be obtained elsewhere. We can all obtain copies of them.

Mr. LEATHER: No you cannot.

Mr. TARRATT: I can get them, and I can arrange for my staff to have them. I say it is a waste of money to publish them in this report; and I ask the Joint Committee to give us something of a practical nature. At the same time, I need hardly say that I appreciate everything Mr. Leather has said, and I thank him and the Committee for the work that is being done.

Mr. J. WILKINSON (Nottingham): I beg to second the motion that the report be received.

Mr. LEATHER, replying to the discussion, said: I do not know that I can say very much with regard to Mr. Gill's reference to practical papers. Of course, Mr. Gardner's paper at Leeds—I am a member of the Council of the Ceramic Society, but unfortunately I was not able to be at the Leeds meeting—was the result of the large amount of research work which he has been engaged in, and his study of the work of others. It is possible to try to be more practical in the work that is done, but, after all, we must have research work. With regard to amending the specification, I have referred to the question of the after-expansion test. This is under discussion, and I was asked by the Committee to get together a quantity of information to enable them to decide what to do. There is a considerable amount of information to be obtained not only from the Association, but also from some of the firms who have laboratories, and some of the larger gas undertakings, in which these tests are made; and I hope before the next annual meeting of the Institution to have collated some of that information.

With regard to refractoriness under load, there is a good deal in what Mr. Gill says; but you must not expect that if a material is said to have a refractoriness of 1700° C., you can work it at anything like that temperature. You have to deal with this much in the same way that you deal with steel. When you are told the working test is 30 tons per sq. in., you would not think of putting on more than 7 or 7½ tons. You must always have a factor of safety. At the same time, the under-load test indicates, if it is properly used, to what extent you can approach the ordinary refractoriness test at the temperature to which you expose the material. It is not, however, such a simple thing. The under-load test, for instance, which was put into the American specification, is not really much use, because they have only one particular test load, and this does not give a great deal of information. You want more than one test; and that means adding a great deal to the expense and time occupied in testing. The papers presented both this year and last year deal with this; but the Committee have not yet seen their way to put anything into the specification. Those, however, who study published research work can see how they can specify it for themselves. The Committee, however, have not yet come to an agreement on the point. The ordinary refractoriness test is not very unsatisfactory. In our Committee we have to secure agreement not only with the manufacturers, but with the users and between the two of them, because there would be no use in publishing a standard test unless it is agreed to by both sides. Thus there is still a little work to be done before we can get to the point of specifying an under-load test.

With regard to the papers published in the report, and Mr. Tarratt's comments, the point is that if anybody does publish these papers without the consent of the Department of Scientific and Industrial Research, they can be pulled up. We have been pulled up more than once, and have had to apologize because there was an accidental reference in the "Clayworker" to some work which had been done and which was the result of research work carried out by the Association. Though Mr. Tarratt says he can get any number of copies, at the same time it is not legal for him to have them.

The report was then adopted.

SERVICE TO THE CONSUMER.

By JOHN W. McLUSKY, of Glasgow, and W. B. McLUSKY, of Halifax.

SECTION I.

ONE ASPECT OF SERVICE TO THE CONSUMER: MAINTENANCE OF APPLIANCES.

By JOHN W. McLUSKY, of Glasgow.

Until recently, the most popular subject in the gas industry was "carbonizing." To-day it has given place to that of "service to the consumer." The change has been effected by the evolution of two processes:

(1) The gradual perfection of carbonizing methods, establishing confidence.

(2) The intensified competition from our respected rival, electricity, disestablishing complacency.

There is no doubt that the carbonizing experts who only require hints from executive gas engineers to make perfect their schemes have enabled the industry to turn naturally from what is rightly reckoned to be "safe territory" to "where the strife is not inglorious, altho' events are dire." How frequently one reads statements akin to the following: "Gas and electricity are very useful commodities, and there is a good field for both." Perfectly true, but how many of us can report that electricity is satisfied with its own field, and is keeping on its own side of the fence? How many of us can report that there is any portion of the fence in existence, especially in the larger areas of supply?

Now the purpose of this brief paper is not to discuss the relative costs of the two commodities, nor to postulate how far the gas accountant may stretch the tenets of his faculty to overtake his compeer in the rival industry in the matter of load factor values, &c.; it is rather to indicate an aspect of service to the consumer which will effectively combat the invader with his attractive schemes which are doubtless familiar to all the members of the Institution. From the point of view of the gas consumer, one of the most popular schemes ever carried out by the gas undertaking of Glasgow is that of "maintenance of all gas consuming appliances in the area of supply." The scheme ensures for the consumers a policy that the gas service will be made attractive and acceptable not only in regard to volume, pressure, and quality, but in the securing of the maximum duty from the gas which they purchase.

The Technical Press has on two previous occasions reviewed the circumstances which compelled the Gas Department of Glasgow to concentrate on such a scheme. It may, therefore, now suffice to describe the scheme as it exists, and append notes on the working costs, which may be higher or lower than other undertakings according to the history of the particular area and the class of work carried out in the "by-gone days."

In working the scheme, the area of gas supply is divided into the wards of the city, and outlying districts are treated separately as districts. In all there are 37 wards and 7 districts.

For every gas consumer a maintenance card (see specimen No. 1, p. 868) is prepared from valuation roll and meter survey records, and when delivered to the maintenance section contains, in addition to the name and address of the consumer, the size and type of meter and "hired" appliances in premises. The number of consumers in each ward averages 10,000.

For easy reference, the cards for each ward are divided into four sections, about 2500 cards per section, and numbered consecutively 1 to 2500.

For the first year and during the establishment of the scheme, one visit in twelve months has been the aim, because of the necessity for extensive renewals. In some of the domestic wards, one man per section is almost able to do this, but in the business and larger wards it is not possible, and two men per section are required. It is anticipated that, after the current year, one man per section in certain domestic wards will give two visits per annum, and in the business wards it is hoped to accomplish two visits per annum with two men per section.

Each maintenance fitter, who is fully qualified, examines meters and connections, overhauls gas lighting burners, greases and repairs taps, waters gasaliers, records the latter, and advises the consumer to have something more up-to-date installed; overhauls cooking and heating appliances, &c., supplying new parts where required, except, of course, in the case of private appliances, where replacements of an expensive character are charged.

All supply piping is carefully fixed with holdfasts, if hanging loose; defective meter connections and Corporation piping between meter and appliance are made good; and gas escapes in private piping are reported to the consumer for the attention of a private plumber, such reports being followed up by inspectors. Gas pressures are recorded with appliances on and off, and tests are made for escapes.

Each maintenance fitter carries application forms for new installations of appliances, and endeavours to secure orders for all types of apparatus. The working day is 8.15 a.m. to 5.30 p.m., with half-an-hour for lunch, equal to $8\frac{3}{4}$ hours per day, and $4\frac{1}{4}$ hours on Saturday. (See fitter's time sheet, specimen No. 2, for recording hours worked per day.) On reporting in the morning, each fitter is given sufficient maintenance cards for the day. These cards are made up the previous day by the clerks, who detail the cards on a "daily card record" (see specimen No. 3). This "daily card record" is handed in the morning to the fitter, who checks it with the number of cards issued to him, initials it, and thereafter hands it to his inspector, who uses the card records for tracing the men during the day. On returning to the depôt in the evening, the fitter hands in his maintenance cards, which are checked by the inspector with the "daily card record" initialled by the fitter in the morning. The cards are then passed to the clerks, who separate finished from unfinished, recording the finished in a daily summary of work done. The finished cards are then filed in their appropriate ward and section, while the "unfinished," which may represent jobs requiring materials from stores, or "no access" to premises, are held-over till the second day after the first visit when they are again given out. In certain instances of unfinished cards or urgent repairs, the cards are given out again the next day.

Each fitter carries a "Requisition for Materials" book (specimen No. 4), the pages of which are in duplicate. All material required for repairs, &c., is put through this book, and requisitions are handed to inspectors nightly.

Inspectors scrutinize and initial, if satisfied they are in order. Each day a number of requisitions are taken out by the inspectors and checked with the job for which they are required; and, if the material is considered necessary, requisitions are passed to the stores. Stores are issued the second day after the first visit.

Inspectors have the supervision of the men in a certain number of wards; the number of men varying from 15 to 20. Each man is visited by an inspector at least every second day, and finished work is checked at random. Inspectors having access to all premises visited by the fitters, make full use of the opportunity afforded to further the use of gas. Each inspector carries a small loose leaf book, containing a list of the wards and districts under his supervision, and for noting any items which may require attention; and he reports daily the work inspected, the number of men visited, and the number of requisitions checked on his district.

Each fitter carries a "Report Card" (specimen No. 5), on which he records escapes of gas in premises visited, and defects at meters which cannot be dealt with by him. A similar card is also used for recording the water-slide gasaliers found in premises visited. Escapes in private pipes are intimated to the consumer by the fitter verbally; and this is followed-up by a circular letter (specimen No. 6) to the consumer. Inspectors follow-up these reported escapes, and record the result in duplicate of letter which is contained in a book.

Semi-skilled men are detailed for radiator watering, which is carried out regularly during the winter months, starting in September. These men clean burners and

loops of radiators, replace broken gauge glasses and washers, and water radiators if necessary. If not checking-down properly, and defect is found, they pass a requisition for materials for repairs, and a fitter is sent to do the work. See "Radiator Watering Card" (specimen No. 7). "No Access Postcards" (specimen No. 8) are carried by fitters, and left in premises after second call. A weekly summary is made up of all work done and material used by fitters; and this is recorded on a summary sheet (specimen No. 9), which gives details of the number of jobs done by each fitter, hours worked, and materials used.

All capped services are noted, and the information is sent to the Sales Section.

All changes in tenancy are noted on maintenance cards by fitters, also additions and removals of hired appliances; and these are inked-in by clerks, and the alterations forwarded to the Survey Section.

RECEPTION OF THE SCHEME.

The scheme has encountered organized opposition from the Master Plumbers' Association of Glasgow; and on several occasions the Gas Committee have received and heard deputations who claimed that the scheme was an invasion into the rightful territory of the master plumbers. These deputations have failed to convince the Gas Committee that the Department's activities were inflicting upon the members of the Association any injustice or hardship, and the scheme still enjoys the support of 90 p.ct. of the membership of the Corporation. The impression made upon the minds of the Gas Committee was: "That the Association were judging and condemning the scheme hastily, and before they had allowed experience to prove that ultimately such a scheme must inevitably create work for the members of the Association." As a matter of fact, there has been quite a demand for better quality fittings and burners, thousands of gas escapes have been reported and made good by the members of the Association, and, what is of more interest to them, thousands of orders have been passed to their members for the fitting-up of new cookers and fires.

The following paragraph extracted from the annual report of the Directors of the Glasgow Master Plumbers' Association proves that the prejudice against the Gas Department is still very much alive: "Attention was drawn to the enlargement of the operations of the Glasgow Gas Department in competition with the plumbing trade; and it was explained that the Directors intended to oppose the action of the Gas Department by every means in their power." It is surprising that such a successful organization should not, in the many years of their existence, have produced a scheme similar to the one they now attack. With the influential support of 721 members, and a clientele of 300,000 gas consumers, coupled with the blessing of the Corporation, it is difficult to imagine that such a scheme could have failed. The fact remains, however, that in the history of the gas supply in Glasgow, dating back to 1818, no constructive proposal to assist the Corporation in popularizing the commodity was ever presented by the Master Plumbers' Association. Let the critics of the scheme demonstrate a better one at 1d. per 1000 c.ft., and the job is theirs.

Apart from this opposition, which springs from deeply-rooted vested interests, the scheme has proved itself to be popular with every class of consumer, because of the infinitely better results obtained from burners and appliances. As a direct result, complaints have been greatly reduced; and it would not be over optimistic to forecast that a well-established scheme in any area would ultimately absorb the complaints staff, removing at the same time many causes for irritation among consumers.

In a speech recently made at a meeting of the National Gas Council, the Chairman, Mr. Milne Watson, urged his hearers (as an effective measure of meeting electrical competition) to put their house in order, and see that their consumers were thoroughly satisfied with the gas service. The Glasgow policy endorses this excellent advice, and has proved it to be propaganda of the best type. There is a spirit of altruism in the scheme which makes a strong appeal; and in the adoption of the best means to attain the most successful ends the highest interests of the community (from the point of view of both the seller and the buyer) are being faithfully served.

LINE OF DEMARCATION BETWEEN GAS FITTING AND MAINTENANCE SECTIONS.

Repair Orders and Complaints Carried out by Maintenance Section.

Refitting meters, inlet and outlet.
Renewing meter stop cocks.
Renewing and refixing meter shelves.
Repairing compo supply to cooking and heating appliances.
Renewing supply to oven burners.

Repair Orders and Complaints Carried out by Fitting Section.

Chokages at service, stair pipes, and crossing (tenements).
Refitting meters involving iron piping.
Altering positions of meters, cooking, and heating appliances.
Refitting of rings and grills.
Escapes at stair pipes and crossings. } (Tenements.)
Refitting of crossings. }
Fitting of gas iron connections.
Securing services not in use with iron plugs and caps, also removing piping and fittings not in use.
Reconnecting appliances.
Renewing compo supplies to Corporation appliances.

SPECIMEN FORMS.

(SPECIMEN No 1.)

[Size of original, 13 in. by 8¾ in.]

DISTRICT Ward No.

Corporation of the City of Glasgow—Gas Department.

O.
P.P.

MAINTENANCE OF APPLIANCES.

Name Address

All appliances fixed on premises to be marked with × in space provided.

	×	Visited	Visited.	Visited.	Visited.	Visited.
Meter....Lt.						
Capped service						
Meter connections						
Governor						
Cooker						
Range fitting						
Griller						
Ring burners						
Hotplate						
Boilers						
Geysers						
Circulators						
Radiators						
Fires						
Gas irons						
Lighting burners						

Consumers are particularly requested not to append their initials unless they are thoroughly satisfied with the work done.

Fitter's initials						
Consumer's initials						

(SPECIMEN No. 2.)

FITTER'S TIME SHEET.

[Size of original, 7 in. by 5 in.]

GLASGOW CORPORATION (GAS)
TIME AND WORK SHEET.
Workman's Name .....No.....
Date.....

District No.	Order. Letter.	Order. No.	NATURE OF WORK.	Time on Job.	Walking Time.	Total Hours

(SPECIMEN No. 3.)

[Size of original, 5½ in. by 5 in.]

GLASGOW CORPORATION GAS DEPARTMENT.

MAINTENANCE SECTION.

DAILY CARD RECORD.

Employee's No..... Date.....

Employee's Name .....

Cards Received .....

Cards Returned.....

Consecutive Nos. .....

.....

Locality .....

.....

Specials: Nos. .....

Locality .....

(SPECIMEN No. 4.)

[Size of original, 5¾ in. by 5 in.]

A 55802

GLASGOW CORPORATION GAS DEPARTMENT.

MAINTENANCE SECTION.

FITTER'S REQUISITION FOR MATERIALS.

Ward No.....

.....192

Maintenance Card No.....

Please supply:

Quantity.	Size.	Materials.

O.Kd.....Inspector. .....Fitter.

(SPECIMEN No. 5.)

[Size of original, 5 in. by 8 in.]

CITY OF GLASGOW GAS DEPARTMENT.

MAINTENANCE OF APPLIANCES REPORT CARD.

Fitter..... Date.....

(SPECIMEN No. 6.)

[Size of original, 4½ in. by 8 in.]

M 7604

GLASGOW CORPORATION GAS DEPARTMENT.

City Chambers—
30, JOHN STREET,
GLASGOW, C. 1.....

.....

.....

.....

Dear Sir or Madam,

Escape of Gas in Premises occupied
by.....
at.....

A Fitter from our Maintenance Section visited above premises on the ..... and found an escape of gas in private pipes. It is essential that the escape be repaired at once, otherwise, as a measure of safety, it may be necessary to disconnect your supply at the meter.

Yours truly,
JOHN W. MCLUSKY,
General Manager.

(SPECIMEN No. 7.)

[Size of original, 8 in. by 5 in.]

District No. ..... Consecutive No.....

Ward No..... Ordy. Maintenance Consec. No.....

GLASGOW CORPORATION GAS DEPARTMENT.

MAINTENANCE SECTION.

RADIATOR WATERING.

No. of RADS.....

.....

Name,.....

Address,.....Street,

Nature of Business,.....

Date	Fitter's No.	Consumer's Initials.	Date.	Fitter's No.	Consumer's Initials.	Date.	Fitter's No.	Consumer's Initials.

On the reverse side of the card is this wording.

MATERIAL.

Date.	Req. No.	Date.	Req. No.

REMARKS.

(SPECIMEN No. 8.)

NO ACCESS POSTCARD.

[Size of original, 5½ in. by 3½ in.]

PRINTED PAPER RATE.

STAMP BEFORE POSTING.

Please call on
..... first,
.....at..... o'clock,
(Signed).....

The Maintenance Office,
GAS DEPARTMENT,
WALLS STREET,
GLASGOW, C. 1.

On the reverse side of the card is this wording:—

Glasgow Corporation Gas Department,
24, Walls Street,
GLASGOW, C.1.....192

Name.....

Address.....

The Maintenance Fitter was unable to obtain access to the above premises to-day. Please fill in on reverse side of this card a date and time at which it will be convenient to call.

.....Fitter,

PLEASE GIVE TWO DAYS CLEAR NOTICE.

(SPECIMEN No. 9.)

SUMMARY SHEET.

[Size of original, 16½ in. wide by 13 in. deep.]

CITY OF GLASGOW GAS DEPARTMENT.

MAINTENANCE OF APPLIANCES.

Summary of Work done and Material used for ending 192

No.	Fitter's Name.	Capped Services.	Meter Connections.	Governors.	Cookers.	Range Fittings.	Grillers.	Ring Burners.	Hot Plates.	Boilers.	Geysers.	Circulators.	Radiators.	Fires.	Gas Irons.	Lighting Burners.
	Total															

MATERIALS DRAWN FROM STOCK.

	Fitter's Name.														
	Totals Cost per unit														
	Total cost														

Cost of Labour, £ : : Cost of Material, £ Total Cost, £ :

Radiator Watering.

—	1st Cycle. Aug. 26, 1924, to Oct. 14, 1924.	2nd Cycle. Dec. 16, 1924, to Feb. 10, 1925.	3rd Cycle. Feb. 17, 1925, to April 30, 1925.
Number watered	4360	4631	4280
Hours taken	1614	1726¼	1388¼
Average per hour	2·70	2·68	3 08
Percentage repaired	9·74	10·08	14·1

—	1st Cycle. Sept. 8, 1925, to Nov. 3, 1925.	2nd Cycle. Nov. 11, 1925, to Jan. 19, 1926.	3rd Cycle. Jan. 19, 1926, to March 23, 1926.
Number watered	6367	6768	8078
Hours taken	2023	2121	2491¼
Average per hour	3·14	3·19	3·24
Percentage repaired	3·5	8	6·8

Escapes in private piping reported to consumers for attention of private plumbers.

Twelve Months—June, 1924, to May, 1925.
Escapes reported . . . . 4063 (Scheme incomplete).

Twelve Months—June, 1925, to May, 1926.
Escapes reported . . . . 6459 (Scheme completed).

Mantles and Globes Broken and Replaced.

—	12 Months. June, 1924, to May, 1925.	Average per Man. Per Year.	Average per Man. Per Month.	12 Months. June, 1925, to May, 1926.	Average per Man. Per Year.	Average per Man. Per Month.
Mantles broken	1223	8	0·7	3392	17·5	1·5
Globes broken	136	0·88	0·07	353	1·42	0·12

Orders Taken on District.

—	12 Months. June, 1924, to May, 1925. Cooking.	Heating.	Total.	12 Months. June, 1925, to May, 1926. Cooking.	Heating.	Total.
Orders for cooking and heating appliances	4125	1233	5358	5278	2497	7775

Statement showing the Scope of Scheme operating in 37 municipal wards and 7 outside areas, comprising the area of gas supply.

Total number of lighting burners	1,124,194
,, ,, ,, domestic cooking appliances	276,931
,, ,, ,, ,, heating appliances	117,424
,, ,, ,, commercial appliances	15,558
,, ,, ,, capped services (potential consumers)	3,090
,, ,, ,, governors	677
,, ,, ,, meter connections	291,324
Grand total	1,830,198

NOTE.—There are 5·28 units per meter under maintenance (excluding the meter and its connections).

Maintenance Costs for the Ten Months ended March 31, 1926.

Number of Appliances and Meters Receiving Attention.	Average Cost per Appliance.	Pence.
1,292,347	Labour	5·11
	Material	1·06
	Oncost	1·22
		7·39

*Cost per Meter Connection.**

Number Receiving Attention.	Cost per Connection.
203,398	3s. 10·97d.

Total Cost in Relation to Gas Made.

Gas Made (10 Months).	Cost per 1000 C.Ft.	Cost per Therm.
C.Ft. 8,599,040,000	Pence. 1·11	Pence. 0·236

* This is the inclusive average cost per meter and all appliances served by same.

SECTION II.

CHARGES FOR GAS AND SERVICE.

THE EQUITABLE DISTRIBUTION OF OVERHEAD CHARGES.

By W. B. McLUSKY, of Halifax.

The maintenance of the consumers' equipment (Section 1) is in itself "equivalent in its economical effects to a reduction in the price of gas,"* but the mode of fixing the price is in need of adjustment.

The flat rate is considered fair and reasonable by those consumers whose consumption of gas is not enough to bring them within the scope of discounts and differential rates, if such there be; and if the flat rate is low, as it is in many towns, the need for special rates or discounts in respect of volume used is perhaps not pressing. Yet, in Widnes, when the ordinary rate was as low as 1s. per 1000 c.ft., a discount of 25 p.ct. was considered expedient for certain (general) purposes.

When the price of gas is relatively high, as it is in many towns to-day, its use for industrial purposes is confined to those processes for which an alternative has not yet been found, and the domestic demand is limited by the user's capacity to pay for gas and other fuel. For the domestic user, gas is the alternative, and he will not spend any part of the weekly fuel allowance on gas if the amount of gas supplied for the money (taking convenience and labour-saving advantages into account) is not equivalent to the fuel displaced. This is not merely an opinion: it is an experience, your experience and mine.

Discounts and differential rates as they are generally applied in the gas industry have failed chiefly because they have been available to only a small proportion of the consumers. Gas managers know from their costs schedules exactly what each group of consumers should pay. Why then do we find what we are pleased to call the price of gas by dividing the total expenditure by the total volume of gas used, and why do we afterwards introduce discounts or differential rates? Because we know that the fictitious figure we have set up and called the price of gas needs adjustment to bring it nearer to the costs schedules. Discounts and rebates begin at the wrong end.

I have made an analysis of the accounts of a number of gas undertakings in this country, and I quote the following, which are typical. We shall describe the towns as A, B, C, D, and E.

—	Works Cost.	All other Expenditure.	Discount of 25 P.Ct. on the Ordinary Price of Gas.	Amount Remaining to Pay all other Expenditure except Works Cost after Deducting Discount.
	Per 1000 C.Ft. of Gas Sold.			
	d.	d.	d.	d.
A	18·73	21·97	11·75	10·22
B	11·83	10·17	7·50	2·67
C	15·30	17·70	8·75	8·95
D	17·47	12·94	8·50	4·44
E	15·60	8·98	6·00	2·98

The discount varies from 6d. to 11·75d. per 1000 c.ft., and the amount available for all other expenditure except works cost varies from 2·67d. to 10·22d.

Discounts, except in very exceptional circumstances, and even then without discrimination, are not intended to encroach upon works cost, but only to return to the consumer the amount which he has paid in excess of his fair share of the overhead charges.

I have illustrated the effect of a 25 p.ct. discount—the amount referred to in the second paragraph. My purpose is to show that this discount is more than 25 p.ct. of the amount which is subject to discount—namely, the overhead charges. In one of the examples cited, the discount is (roundly) 50 p.ct. of these charges, in another 66 p.ct., and in a third 75 p.ct. Discounts applied in this way affect every 1000 c.ft. of gas consumed, which is wrong in principle. Under a two-part scale of charges, no consumer

* London Gas Referees' Report on Improvements in Consumers' Burners 1873.

gets any rebate or discount *until he has discharged his obligations* in respect of fixed charges.

If the Halifax system of distributing these overhead charges was applied, the consumer who used 10 million c.ft. of gas per annum would pay in respect of *all charges* a sum representing 2s. 2·4d. per 1000 c.ft. of gas supplied, and at the same time contribute 7·67d. per 1000 c.ft. towards all other expenditure except works cost. One of the smallest householders using 82,000 c.ft. through a 1-in. service pipe would pay a sum representing 2s. 5·71d. per 1000 c.ft., and contribute 10·98d. per 1000 c.ft. towards all other expenditure. In each and every case the consumer gets the commodity at an appropriate price, and he gets it at his own expense—not at the expense of his neighbour—by burning gas.

The consumer who represents what is called the "small householder"—not always the small user relative to the amount of money spent in providing the installation and maintaining the supply of gas—says "Let us all pay alike," but this would impose an intolerable burden upon every consumer whose consumption of gas in any year was less than the average consumption per consumer in that town, as the following examples will prove.

Town.	Number of Consumers.	Average Consumption per Consumer.	Gas-Works Cost.	All other Expenditure except Works Cost.	
				Per 1000 C.Ft.	Per Consumer.
(1)	(2)	(3)	(4)	(5)	(6)
		C.Ft.	d.	d.	£ s. d.
A . .	32,090	26,560	18·73	21·97	2 8 7¾
B . .	6,960	23,275	11·83	10·17	19 8¾
C . .	120,266	40,252	15·30	17·70	2 19 5
D . .	202,775	61,788	17·47	12·94	3 6 8
E . .	20,221	52,365	15·60	8·98	1 19 2

If every consumer paid a fixed charge per annum amounting to the sum shown in column (6), every consumer could have his gas supply at the works cost—the sum shown in column (4).

The overhead charges per 1000 c.ft. of gas sold in towns B, D, and E are low for different reasons—B and E because the unredeemed debt on the undertaking is low; D because the volume of gas sold per consumer per annum is high.

These figures focus attention on the fact that the cost of production—however low it may be—is of less value to the consumer than the large consumption per service pipe.

The undertaking described here as D enjoys an honoured place among undertakings with a very low capital charge per 1000 c.ft. of gas sold—viz., 4d.* per 1000 c.ft.—but, as we have seen, this low figure is not due so much to a low working capital as to a high consumption per service pipe.

A perfect understanding of these figures would remove all misunderstanding between the consumer and the gas undertaking. Of course, it is not suggested that the small consumer should pay a fixed charge levied on the *average*, as shown here, any more than he should pay a flat rate which is found precisely by the same process.

It is better to distribute these overhead charges equitably between the small and the large consumer, as is done in Halifax, where the smallest householder pays a fixed charge of 39s. per annum, and the smallest industrial user £2 per annum. The highest charge for domestic purposes on our books to-day is £9 10s. 8d. per annum, the highest fixed charge for industrial or commercial purposes is £450 per annum, and for public lighting £2220 per annum. The price of gas is the same to everyone so long as he continues to pay for gas.

Persistent efforts have been made in this country from time to time to form a basis for the charges for gas. To Mr. George Anderson, of 5, Victoria Street, London, S.W. 1, and Mr. Henry L. Doherty, the eminent American Gas Administrator (see Technical Press, 1900), probably belongs the credit for the first attempt in this direction.

In the year 1901 Mr. Anderson related to me his first experience with an ordinary rate for the tabulated consumption, and a lower rate for all gas used in excess of that amount. The tabulated quantity was determined mainly upon the basis of the quantity of gas used in the same premises by the same consumer over a previous corresponding period. At that date my own first two-part scale had been in operation for only a year or two, and was limited to coin meter supply.

My second scale was produced in 1905, and included all gas supplied for non-lighting purposes. This was the beginning of the now well-known Perth parcels scheme, which has proved so useful throughout the gas industry, and in electricity and water supply as well.

The following is a copy of the original Perth scale:

PERTH PARCELS SCALE.

	s.	d.	
1st 100,000 c.ft. per annum . . .	2	6	per 1000 c.ft.
2nd ,, ,, ,, . . .	2	4	,, ,, ,,
3rd ,, ,, ,, . . .	2	2	,, ,, ,,
4th ,, ,, ,, . . .	2	0	,, ,, ,,
5th ,, ,, ,, . . .	1	10	,, ,, ,,
6th ,, ,, ,, . . .	1	8	,, ,, ,,
7th ,, ,, ,, . . .	1	6	,, ,, ,,
8th ,, ,, ,, . . .	1	4	,, ,, ,,
9th ,, ,, ,, . . .	1	2	,, ,, ,,
10th ,, ,, ,, . . .	1	0	,, ,, ,,
	s.	d.	
Average for the 1st million c.ft. per annum	1	9	per 1000 c.ft.
Price ,, ,, 2nd ,, ,, ,,	1	6	,, ,, ,,
Price ,, ,, 3rd ,, ,, and all in excess of 3 million c.ft. per annum .	1	4½	,, ,, ,,

The feature of the Perth parcels scale is that every consumer pays as little as his neighbour so long as he continues to pay, and therefore cannot complain if his neighbour follows on to the lower rates, and pays more money in the aggregate to the gas undertaking. The fault of the scheme is that it does not go far enough. The intermittent user with a large hourly demand involving much capital expenditure pays no more in a quarter for the volume of gas consumed under this scheme than the small consumer who, with a small but regular long-period demand, uses as much gas with a much smaller and less expensive installation. This defect is removed in the Halifax scales of charges, which are as follows:

GROUP C.—*Commercial and Industrial Purposes.*

£2 per annum per horse-power, or the equivalent of horse-power (20 c.ft. per hour) demanded. All gas used is charged according to the following scale:

s.	d.					
2	0	per 1000 c.ft.	for the	1st	million c.ft.	per annum.
1	9	,,	,,	2nd	,, ,,	,,
1	6	,,	,,	3rd	,, ,,	,,
1	3	,,	,,	4th	,,	and all in excess of 4 million c.ft. per annum.

NOTE.—There is a "purposes" group for industrial users with a separate and invariable multiple of the horse-power, or the equivalent of horse-power, demanded in each of the six divisions in the group.

This scale is optional. For any one premises only one meter is provided by the authority. There is an alternative scale for commercial and industrial purposes as follows:

GROUP D.—*Commercial and Industrial Purposes.*

LIGHTING.

s.	d.					
3	11	per 1000 c.ft.	for the	1st	100,000 c.ft.	per quarter.
3	10	,,	,,	2nd	,, ,,	,,
3	9	,,	,,	3rd	,, ,,	,,
3	8	,,	,,	4th	,, ,,	,,
3	7	,,	,,	5th	,, ,,	,,
3	5	,,	,,	all in excess of 500,000 c.ft. per *quarter*.		

NON-LIGHTING.

s.	d.					
3	5	per 1000 c.ft.	for the	1st	million c.ft.	per quarter.
2	11	,,	,,	2nd	,, ,,	,,
2	5	,,	,,	3rd	,,	and all in excess of 3 million c.ft. per *quarter*.

GROUP D.—*Domestic Purposes.*

The same scales as Group D.—Commercial and Industrial Purposes.

GROUP A.—*Standard Requirements Scheme.*

In residences consumers may elect to adopt the "Standard Requirement" scheme, whereby the gas used in excess of the ascertained standard requirement will be charged at the non-lighting rates. This scheme applies equally to every residence, as follows:

The standard requirement is 37½ c.ft. of gas per annum per superficial foot of floor area of the living and reception rooms. This standard volume is charged at the lighting rate, and all gas used in excess of this volume is charged at the non-lighting rate.

In premises lighted mainly by electricity, the gas burners in use shall be separately assessed to arrive at the standard requirement for lighting purposes per annum.

NOTE.—This scheme is unique in one respect—namely, that the quantity of gas charged at the ordinary price (Group D) varies according to the size of the consumer's premises. When the scheme was introduced, in 1912, the superficial area of the living and reception rooms was multiplied by 40 c.ft. to arrive at the standard requirement set out in column 1, Group B.

During the war the multiple was 75 c.ft. of gas per superficial foot of floor area, but in 1922 this figure was reduced to 37½ c.ft., the present multiple.

An addition sum of the "Standard Requirements" of *all* residences in the area of supply would represent the total amount of gas required for domestic lighting purposes for the year—375,000,000 c.ft. in the case of Halifax.

* A special credit made this figure less for the year 1924-25.

GROUP B.—*Two-Part Scheme.*

s. d.
2 0 per 1000 c.ft. for the 1st million c.ft. per annum.
1 9 ,, ,, 2nd ,, ,, ,,
1 6 ,, ,, 3rd ,, ,, ,,
1 3 ,, ,, 4th ,, and all in excess of 4 million c.ft. per *annum*.

Plus the following scale of fixed charges per quarter:

Amount of Standard Requirement per Annum. (1)	Fixed Charge per Quarter. (2)
	s. d.
Division (1) 9,000 c.ft. or less	9 9
,, (2) 10,000 ,, ,,	10 10
,, (3) 11,000 ,, ,,	11 11
,, (4) 12,000 ,, ,,	13 0
,, (5) 13,000 ,, ,,	14 1
,, (6) 14,000 ,, ,,	15 2
,, (7) 15,000 ,, ,,	16 3
,, (8) 16,000 ,, ,,	17 4
,, (9) 17,000 ,, ,,	18 5
,, (10) 18,000 ,, ,,	19 6
,, (11) 19,000 ,, ,,	20 7
,, (12) 20,000 ,, ,,	21 8
,, (13) 21,000 ,, ,,	22 9
,, (14) 22,000 ,, ,,	23 10
,, (15) 23,000 ,, ,,	24 11
,, (16) 24,000 ,, ,,	26 0

and so on at the rate of 13d. per quarter for each 1000 c.ft. or part of 1000 c.ft. in the standard requirement.

NOTE.—The *denominator* in the standard requirement represents the number of pence required per week to meet all other expenditure excepting works cost. If every consumer adopted the scheme, an addition sum of these pence would amount to the total sum required to meet all *overhead charges* in connection with domestic supply. The works cost, as we have seen, is levied on the volume basis and recovered as the price per 1000 c.ft. consumed.

GROUP E.—*Coin Meter Supply.*

s. d.
4 2 per 1000 c.ft. up to 6000 c.ft. per quarter.
3 9 ,, ,, for all gas used in excess of 6000 c.ft. per quarter.

NOTE.—This charge covers the rent of the meter and a small cooking stove, boiling burner, breakfast cooker, or gas iron. Any *one* of these appliances is supplied free, and fixed for the consumer free of charge.

GROUPS A, B, C, and E *are entirely optional.*

The effect of these scales can best be illustrated by the following extracts from our books.

(*a*) COMMERCIAL AND INDUSTRIAL (GROUP C).—A consumer who burns 10,000,000 c.ft. per annum pays an average price of 2s. 2·40d. per 1000 c.ft., as follows:

	£ s. d.	Per 1000 C.Ft. s. d.
Gas—1,000,000 c.ft. at 2 0		
1,000,000 ,, ,, 1 9		
1,000,000 ,, ,, 1 6		
7,000,000 ,, ,, 1 3		
	700 0 0 ..	1 4·80
Fixed charge—200 H.P. at £2 per annum	400 0 0 ..	0 9·60
Total	£1100 0 0 ..	2 2·40
Works cost		1 6·73
Amount available for all other expenditure		0 7·67d.

(*b*) DOMESTIC (GROUP B, DIVISION 34).—A consumer who burns 649,000 c.ft. per annum pays an average price of 2s. 3·36d. per 1000 c.ft., as follows:

	£ s. d.	Per 1000 C.Ft. s. d.
Gas—649,000 c.ft. at 2s.	64 18 0 ..	2 0·00
Fixed charge per annum	9 2 0 ..	0 3·36
Total	£74 0 0 ..	2 3·36
Works cost		1 6·73
Amount available for all other expenditure		0 8·63d.

(*c*) DOMESTIC (GROUP B, DIVISION 7).—A consumer who burns 220,000 c.ft. per annum pays an average price of 2s. 3·55d. per 1000 c.ft., as follows:

	£ s. d.	Per 1000 C.Ft. s. d.
Gas—220,000 c.ft. at 2s.	22 0 0 ..	2 0·00
Fixed charge per annum	3 5 0 ..	0 3·55
Total	£25 5 0 ..	2 3·55
Works cost		1 6·73
Amount available for all other expenditure		0 8 82d.

(*d*) DOMESTIC (GROUP B, DIVISION 1).—A consumer who burns 82,000 c.ft. per annum pays an average price of 2s. 5 71d. per 1000 c.ft., as follows:

	£ s. d.	Per 1000 C.Ft. s. d.
Gas—82,000 c.ft. at 2s.	8 4 0 ..	2 0·00
Fixed charge per annum	1 19 0 ..	0 5·71
Total	£10 3 0 ..	2 5·71
Works cost		1 6·73
Amount available to meet all other expenditure		0 10·98d.

NOTE.—The load factor in a number of residences in Halifax is about 64 p.ct.—3600 hours per annum.

The following are examples of consumers who find it of advantage to buy gas at the flat rate.

(*e*) DOMESTIC (GROUP D).—A consumer who burns only 8000 c.ft. per annum pays a flat rate of 3s. 11d. to meet the average price required—10s. 1½d. per 1000 c.ft.

	£ s. d.	Per 1000 C.Ft. s. d.
Gas—8000 c.ft. at 2s.	0 16 0 ..	2 0·00
Fixed charge per annum	3 5 0 ..	8 1·50
Total	£4 1 0 ..	10 1·50
Price paid flat rate		3 11·00
Deficiency		6 2·50d.

A consumption of 34,000 c.ft. per annum would make the average price received 3s. 11d.

(*f*) DOMESTIC (GROUP D).—A consumer who burns only 11,000 c.ft. per annum and pays a flat rate of 3s. 11d. to meet the average price required—5s. 6·54d. per 1000 c.ft.

	£ s. d.	Per 1000 C.Ft. s. d.
Gas—11,000 c.ft. at 2s.	1 2 0 ..	2 0·00
Fixed charge per annum	1 19 0 ..	3 6·54
Total	£3 1 0 ..	5 6·54
Price paid flat rate		3 11·00
Deficiency		1 7·54d.

A consumption of 20,000 c.ft. per annum would make the average price received 3s. 11d.

Whatever statistics may reveal, it is the small consumer who is the potential large user of gas, if good facilities are offered and the sales department is active.

The business brought by 1000 small consumers is more secure than an equal volume of trade with one person or firm. A mixed business, industrial, commercial, and domestic, is best and withstands competition better than any other.

The depression in trade during the past five years has reduced the industrial demand in Halifax by over 135 million c.ft. per annum. The "domestic and small premises" demand has increased in the same period by 170 million c.ft., making a net increase of 35 millions per annum in the sale of gas, apart from and in addition to the recovery of 24 million c.ft. for public lighting. These increases have been obtained in face of competition. Depression in trade has affected the industrial demand for electricity too, and the Halifax Municipal Electricity Supply Undertaking has been active in the domestic and other fields.

The Halifax scales of charges have appealed not merely to regular users of gas. The best customers of the electricity department are numbered among the largest users of gas for non-lighting purposes, in spite of the Norwich scale of charges for domestic electricity supply. It may be suggested that equally large quantities of gas would be used in residences in Halifax if ordinary flat rates were charged. Experience proves the contrary. When gas is supplied at approximately works cost *plus* a fixed charge the consumer regards the fixed charge as a rent which he is entitled to pay; and the small running cost stimulates the use of gas in place of raw coal.

The existing inequitable system of levying the charges, and nothing else, stands between the gas industry and a large increase in business.

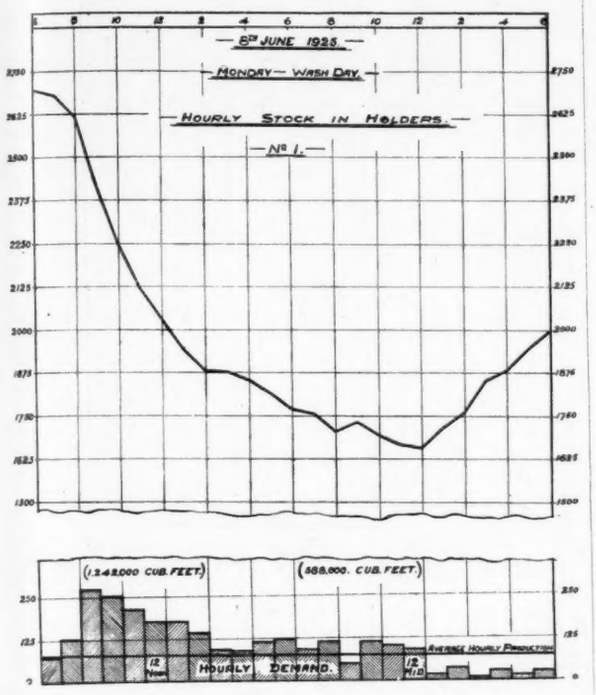
The industry is organized to cope with sudden demands for gas for *any* purpose at *any* hour without any increase in manufacturing charges. Charts Nos. 1 to 6 (appended) relating to Halifax gas supply prove this. Therefore the fine classification of rates which are really necessary for electricity supply are not required for the sale of gas.

The Halifax scales are simple, and clearly understood by the consumer. They are entirely voluntary, and established within the law as it stands. But, as I stated at Oldham in 1923, some modification of the clauses relating to calculations in respect of dividends would be necessary so that the average price received for gas might be accepted for such calculations.

Many consumers living in small houses are using gas in place of coal to a large extent, as the following example will show:

GAS AT FLAT RATE.

—	Per Week.	Per Quarter.
	s. d.	s. d.
Coal (2 cwt.)	4 2	54 2
Gas (250 c.ft.)	0 10	10 10
Total expenditure	5 0	65 0

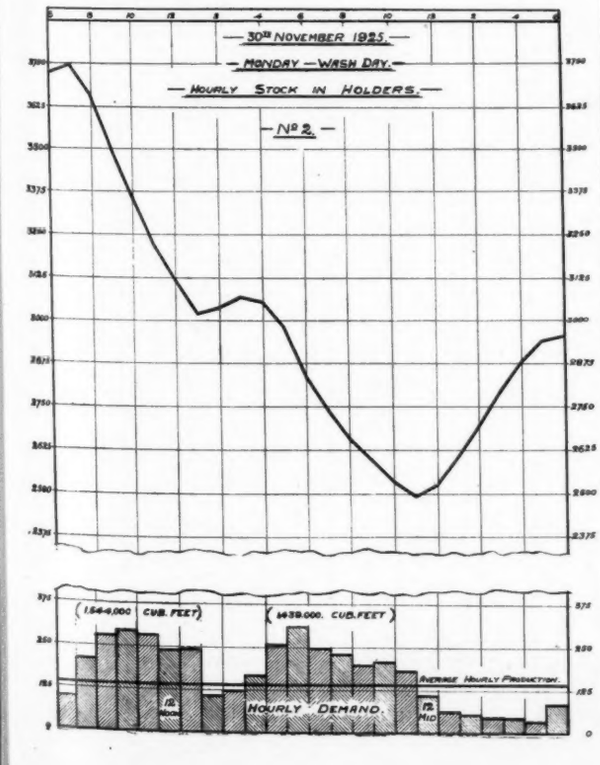


GROUP B.—Two-Part Scale.

—	Per Week.	Per Quarter.
	s. d.	s. d.
Coal (1 cwt.)	2 1	27 1
Gas (1000 c.ft.)	2 0	26 0
Gas, fixed charge	0 11	11 11
Total expenditure	5 0	65 0

The consumer's weekly expenditure is not increased, but the revenue of the gas department is increased from 10d. to 2s. 11d.—a gross increase of 2s. 1d. per week, and a net gain of 11d. per week, after deducting the works cost of providing the gas. This is very remarkable: the average receipts amount to only 1s. 10½d. per consumer per week.

It is not so much a question of capital outlay; it is one of long period demand. Here is an example of a consumer using 160,000 c.ft. of gas through a service pipe 1¼ in. in diameter.



GROUP B.—Two-Part Scale.

Number of living and reception rooms . 2.
Area of living and reception rooms. . . 240 sup. ft.
Standard requirement of premises . . 9000 c ft.
Gas consumed . . . . . 160,000 c.ft. per annum.

REVENUE.

	£ s. d.
Fixed charge per annum.	1 19 0
Gas—160,000 c.ft. at 2s.	16 0 0
Total	£17 19 0

Average price received, 2s. 2·92d. per 1000 c.ft, compared with 2s. 2·40d.—the average price received from the consumer who used 10 million c.ft. of gas under Group C scale.

The ordinary lighting year in this country averages. . . . . 1600 hours = 18·26 p.c. of the total number of hours in the year.

The industrial year equals on the average 40 hours per week 40 weeks per annum . . . . . 1600 hours = 18·26 p.c. do.

The industrial year for a full week of 47 hours and 50 weeks per annum equals. . . . . 2350 hours = 26·82 p.c. do.

NOTE.—This figure is increased where more than one shift is worked.

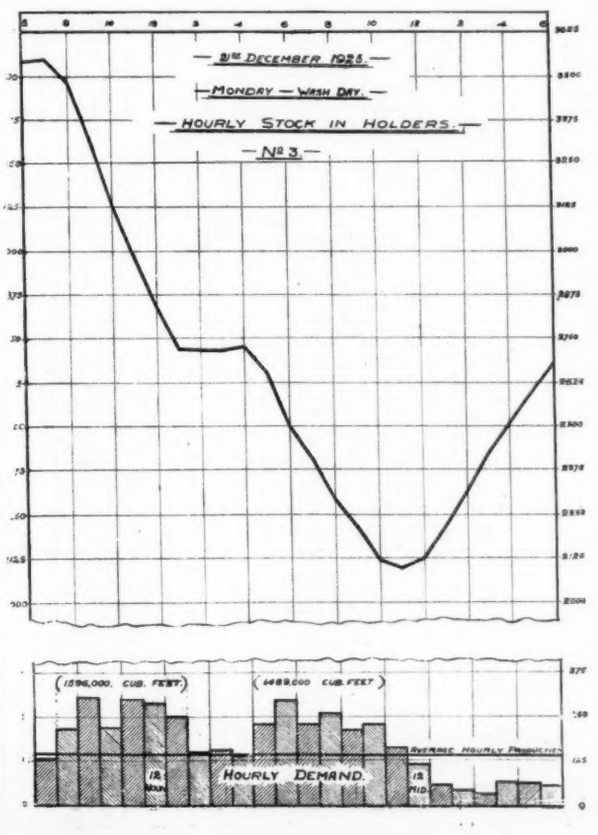
The domestic year is made up of various requirements for an increasing variety of purposes and the demand is spread over a large number of hours per annum—in Halifax the number of hours now reached is. . . 3099 hours = 35·38 p.c. do.

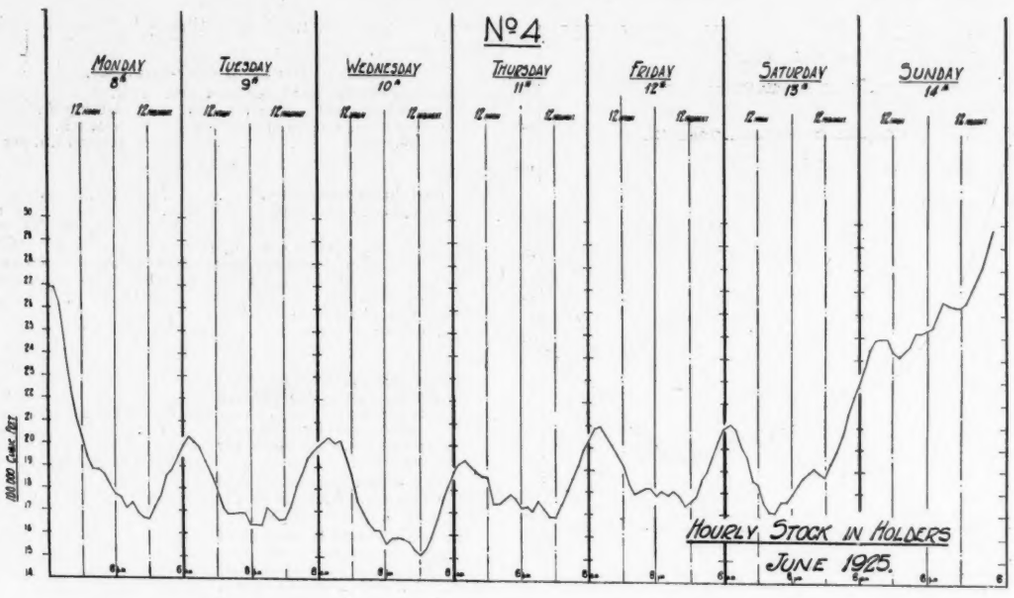
Our output charts Nos. 1 to 6 show this.

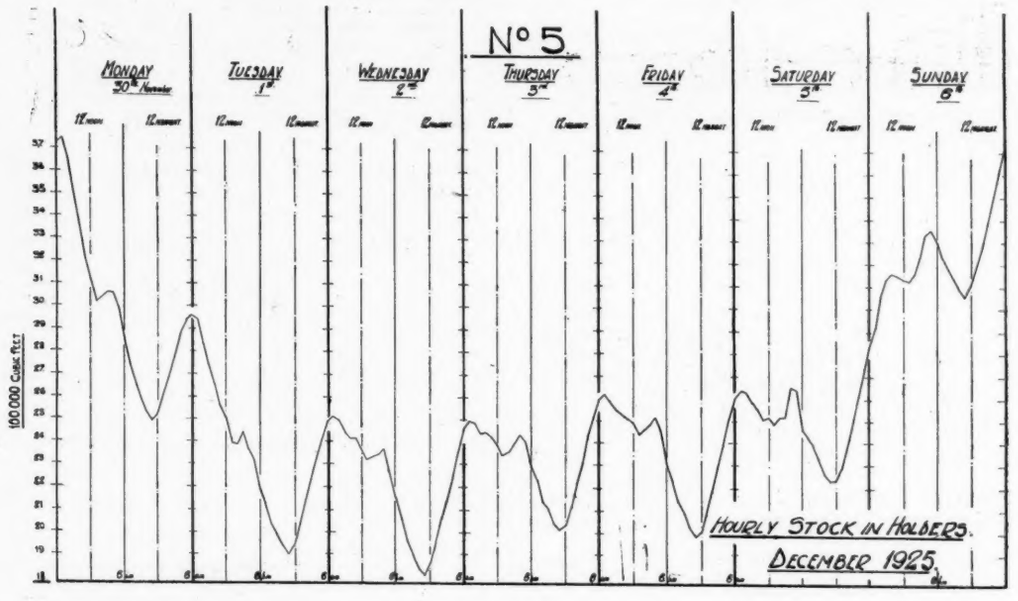
The gasholders begin to descend at 6 o'clock in the morning, and the replenishment of the stock does not begin until 11 p.m. (normal time) in summer, and 10.30 p.m. in winter. The busiest six hours of the day are the morning hours, 7 a.m. to 1 p.m., inclusive. The next busiest period is 4 p.m. to 10 p.m., inclusive.

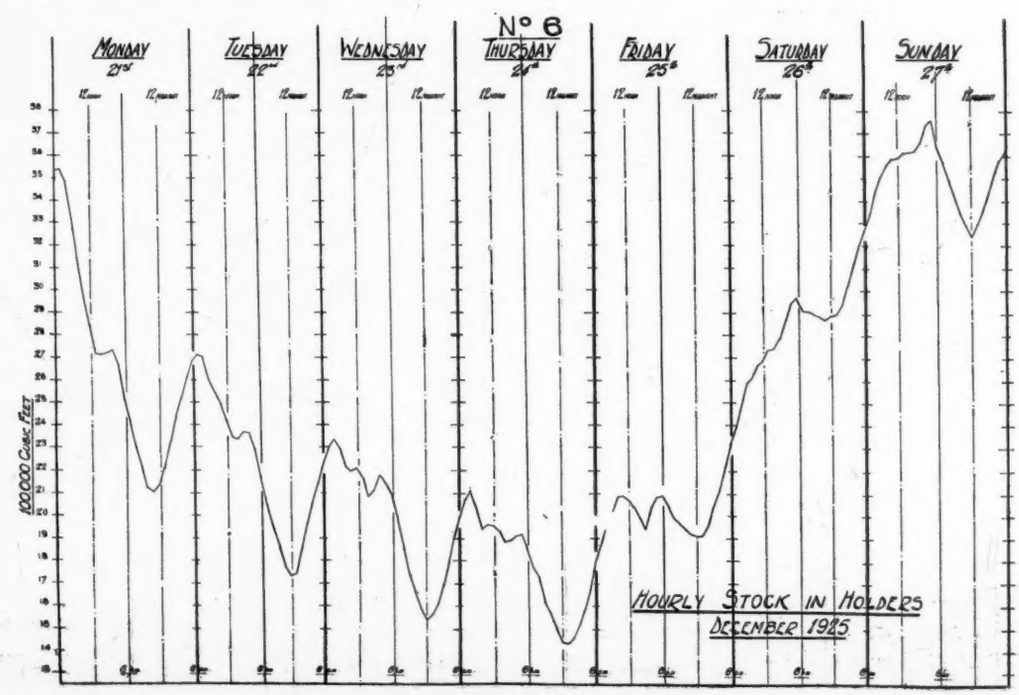
Year 1925.	Period.	Output.
		C.Ft.
December	7 a.m. to 1 p.m.	1,596,000
	4 p.m. to 10 p.m.	1,489,000
November	7 a.m. to 1 p.m.	1,544,000
	4 p.m. to 10 p.m.	1,439,000
June	7 a.m. to 1 p.m.	1,242,000
	4 p.m. to 10 p.m.	588,000

The demand during one of the six morning hours in June multiplied by 3099 hours per annum gives us the




No 4
MONDAY 8th
TUESDAY 9th
WEDNESDAY 10th
THURSDAY 11th
FRIDAY 12th
SATURDAY 13th
SUNDAY 14th
100,000 Cubic Feet
HOURLY STOCK IN HOLDERS
JUNE 1925.


No 5
MONDAY 30th November
TUESDAY 1st
WEDNESDAY 2nd
THURSDAY 3rd
FRIDAY 4th
SATURDAY 5th
SUNDAY 6th
100,000 Cubic Feet
HOURLY STOCK IN HOLDERS.
DECEMBER 1925.


No 6
MONDAY 21st
TUESDAY 22nd
WEDNESDAY 23rd
THURSDAY 24th
FRIDAY 25th
SATURDAY 26th
SUNDAY 27th
100,000 Cubic Feet
HOURLY STOCK IN HOLDERS
DECEMBER 1925

sale of gas for a year in Halifax—853,334,100 c.ft. That means that the consumers on the average are using their maximum demand during 3099 hours of the year, equal to a load factor of 35·38 p.ct., compared with a lighting year of 18·26 p.ct. The only period of the day during which gas is not used to any extent is between 12 midnight and 5 a.m., and as the Weekly Charts (Nos. 4 to 6) show, that period is useful for the replenishment of stocks.

It might be argued that, if every consumer used 160,000 c.ft. of gas per annum at the rates named, the additional capital required to meet the growth of the business would necessitate an increase in the fixed charges per consumer. We have examined this question very carefully, and are satisfied that the new business is not due to an increase in the consumer's maximum hourly demand, but to a longer period of use. Experience has proved that no further capital is required for an increase of this kind.

If, however, the average consumption per consumer increased from the present figure of 26,560 c.ft. to 160,000 c.ft. per annum, further expenditure would be required for the enlargement—not extension—of certain mains. This would be a small item in Halifax, as ten miles of high-pressure mains are already at work, and capable of more work. The bulk of the new expenditure would be required for the extension of the manufacturing plant, and this new manufacturing plant would be occupied for a greater number of days in the year. Plant that is idle from March to October at the present time would be fully employed except for that portion (20 p.ct.) held in reserve for repairs. Against this expenditure we should have a revenue of, roughly, £17 19s. per consumer on the 160,000 c.ft. basis, compared with £5 3s. 10d.—the average amount received if every consumer used the average quantity and paid the flat rate. The difference between these two sums—namely, £12 15s. 2d. per consumer per annum—represents an increased income of £402,266 13s. 4d., subject to deduction for works cost, which in Halifax and in most towns would be reduced with a properly-balanced demand. Even though works cost did not come below 1s. 6d. per 1000 c.ft. (which includes repairs and maintenance on a generous scale, £319,200 per annum for the additional quantity of gas required), we should have a net gain of £89,066, more than enough to meet interest and depreciation on the new capital required for a business with such a large load factor.

Since we started the "floor area" and "two-part" schemes in this country many years ago similar schemes have been doing good work in the United States of America and probably in other parts of the world. It is my privilege and pleasure to append the following particulars which I have adduced from the information supplied to me by our friends and compatriots Douglass Burnett, of Baltimore, and T. V. Purcell, Vice-President of the People's Gas Light and Coke Company, Chicago. For the purpose of comparison I have translated the Halifax scales into the currency of the United States.

BALTIMORE, MARYLAND.

SCHEDULE C.—*Yearly Contract. General Rate, by Agreement. A Two-Part Tariff.*

The first part is based upon 150 hours' use per month of the maximum hourly demand, but shall in no case be taken at less than 4000 c.ft. per month, value $3 40c. (14s. 2d.). The demand is fixed "by the burner rating or otherwise," and shall in no case be less than 75 p.ct. of the amount of gas which "continuous use for one hour would require."

The first part is charged at 85 c. (3s. 6½d.)
The second ,, ,, ,, 65 c. (2s. 8½d.)

Not more than two meters are furnished free for any premises.

Rents charged for additional meters—
Main meters . . 2 dollars 50 cents. (10s. 5d.) per month
Check meters . 1 dollar (4s. 2d.) ,,

SCHEDULE C.H.—*Commercial Heating Gas Rates. (A supplement of Schedule C.)*

Where the capacity of the mains in any district is sufficient for this class of business, gas will be supplied under this schedule "solely at the Company's option" for the heating of schools, large stores, theatres, offices, apartment-houses, hotels, &c.—provided no fuel but gas is used for the heating of such premises, and where the floor area of the premises is in excess of 5000 sq. ft.

The volume of gas used is charged in two parts.

The first part is rated at 85 c. (3s. 6½d.)
The second ,, ,, ,, 65 c. (2s. 8½d.)

The part to be charged at the higher rate is found by multiplying the floor area of the room by 10 up to 1000 sq. ft. of floor area. The multiple is reduced to 4 for all areas in excess of 1000 sq. ft.

Thus:

Floor Area, 6000 Sq. Ft.

Sq. Ft. of Space.	C.Ft. of Gas.	Rate.
		s. d.
1000	10,000	3 6½
5000	20,000	2 8½

The secondary rate does not apply if the second quantity is less than 4000 c.ft.

SCHEDULE D.—*Domestic Service, by Agreement.*

This scheme was started in the year 1916, and may be briefly described as follows: 85 c. (3s. 6½d.) per 1000 c.ft. is charged for the first "parcel" consumed per month. All gas used in excess of that quantity monthly is charged at the lower rate—namely, 65 c. (2s. 8½d.) per 1000 c.ft.

New Customers and Present Customers in New Houses.

The volume of gas charged at the higher (called the primary) rate varies according to the size of the house; the variant being the number of rooms, and not the area of the rooms, as in the Halifax scheme. This scheme includes all rooms except cellars, closets, pantries, and store-rooms. The Halifax fixed charges are based upon the areas of the living and reception rooms alone.

Baltimore Domestic Scale.

Number of Rooms.	Quantity of Gas per Month Charged at the Higher or Primary Rate.
6 or less	4,000 c.ft.
7	5,000 ,,
8	6,000 ,,
9	7,000 ,,
10	8,000 ,,
11	9,000 ,,
12	10,000 ,,

With an excess of 1000 c.ft. per room per month for each room over 12.

One meter for each house, as in Halifax.

Regular Customers.

The first parcel is tabulated on the basis of the maximum consumption by the customer in any month during the previous twelve months at the same premises.

SCHEDULE K.—*Industrial Rates. General Service. A Three-Part Tariff.*

The customer who accepts this service must sign a contract for three years. No maintenance is furnished under this schedule. Contracts may be renewed for periods of one year.

FIXED CHARGES PER ANNUM.

	Corresponding Figure in Halifax.
$204 = £42 10s. for the first 300 c.ft. per hour of the demand = 56s. 8d. per 20 c.ft. of the demand	£2 per 20 c.ft. of the demand
$24 = £5 per 100 c.ft. is charged for that part of the demand which is in excess of 300 c.ft. per hour	£2 do.

The maximum demand is taken at "not less than 75 p.ct. of the amount of gas which continuous use for one hour would require."

COMMODITY CHARGE.

	s.	d.
55 c. (2s. 3½d.) per 1000 c.ft. for the first 1,000,000 c.ft. per month	1	4·50
50 c. (2s. 1d.) per 1000 c.ft. for all gas used in excess of 1,000,000 c.ft. up to 5,000,000 c.ft. per month	1	3·30
45 c. (1s. 10½d.) for all gas used in excess of 5,000,000 c.ft. per month	1	3·00

1.—GROUP B. DIVISION 34.

Size of house . . . . . 12 rooms
Appliances Installed—
1 gas cooker
1 gas copper
1 water heater
8 gas fires
2 radiators
Size of service . . . . . 2 in.
Consumption per annum . . . . 649,000 c.ft.
Standard requirements . . . . . 42,000 c.ft.
Fixed charge . . . . . £2 5s. 6d. per qr.

3.—GROUP B. DIVISION 7.

Size of house . . . . . 6 rooms
Appliances Installed—
2 gas fires
1 gas cooker
1 gas copper
Size of service . . . . . 1 in.
Consumption per annum . . . . 107,000 c.ft.
Standard requirements . . . . . 15,000 c.ft.
Fixed charge . . . . . 16s. 3d. per qr.

2.—GROUP B. DIVISION 7.

Size of house . . . . . 6 rooms
Appliances Installed—
2 gas fires
1 gas cooker
1 copper
Size of service . . . . . ¾ in.
Consumption per annum . . . . 121,000 c.ft.
Standard requirements . . . . . 15,000 c.ft.
Fixed charge . . . . . 16s. 3d. per qr.

4.—GROUP B. DIVISION 1.

Size of house . . . . . 4 rooms
Appliances Installed—
1 gas cooker
1 gas copper
Size of service . . . . . ¾ in.
Consumption per annum . . . . 82,000 c.ft.
Standard requirements . . . . . 9,000 c.ft.
Fixed charges . . . . . 9s. 9d. per qr.

CHICAGO, ILLINOIS.

CLASSIFICATION NO. 1.—*Rates for General Use.*

C.Ft. of Gas Consumed in any One Month.	Rate.	Equivalent per 1000 C.Ft. in British Currency.
	c.	s. d.
For the first 400 c.ft.	60	6 3
,, ,, next 9,600 ,,	per 1000 c.ft. 95	3 11½
,, ,, ,, 40,000 ,,	,, ,, ,, 90	3 9
,, all over 50,000 ,,	,, ,, ,, 85	3 6½

Minimum charge per month, 60 c. = 2s. 6d.

CLASSIFICATION NO. 2.—*Sliding Scale—Two Part Tariff*

DEMAND CHARGE.

—	Total per Annum.	Corresponding Figure in Halifax—£2 per 20 c.ft. of the Demand.
	£ s.	£ s.
12 c. (6d.) per c.ft. for the first 50 c.ft. of the maximum hourly demand in any month	15 0	5 0
4 c. (2d.) per c.ft. for the next 50 c.ft. of the maximum hourly demand in any month	5 0	5 0
3 c. (1½d.) per c.ft. for the next 900 c.ft. of the maximum hourly demand in any month	67 10	90 0
2 c. (1d.) per c.ft. in excess of the maximum demand in the month over 1000 c.ft.	0 1	0 2

Corresponding Figure for Halifax.

Thus, for the first 50 H.P., the fixed charge is £87 10s. .. £100
,, ,, second 50 ,, ,, ,, £50. .. £100

The maximum demand is deemed to be twice the amount of gas consumed in any half-hour.

COMMODITY CHARGE.—For Gas Consumed.

75 c. (3s. 1½d.) per 1000 c.ft. for the first 1,000,000 c.ft. consumed in any month.
70 c. (2s. 11d.) per 1000 c.ft. for the next 1,000,000 c.ft. consumed in any month.
65 c. (2s. 8½d.) per 1000 c.ft. for the next 1,000,000 c.ft. consumed in any month.
60 c. (2s. 6d.) per 1000 c.ft. for the excess consumption over 3,000,000 c.ft. in any month.

Discount 3 p.ct. provided the account is paid monthly "within ten days after its date."

MINIMUM CHARGE.

The total payment for any month's service shall be not less than 50 p ct. of the highest previous monthly demand charge since the beginning of the contract.

CLASSIFICATION NO. 3.—*House or Space Heating.*

C.Ft. of Gas Consumed in any One Month.	Rate.	Equivalent per 1000 C.Ft.
		s. d.
For the first 400 c.ft.	60 c.	6 3
,, ,, next 2600 ,,	95 c. per 1000 c.ft.	3 11½
,, all over 3000 ,,	75 c. ,, ,, ,,	3 1½

The customer guarantees a consumption of gas which will equal $24 (£5) per annum.

No account is rendered during the months when gas is not being used.

5.—GROUP B. DIVISION 1.

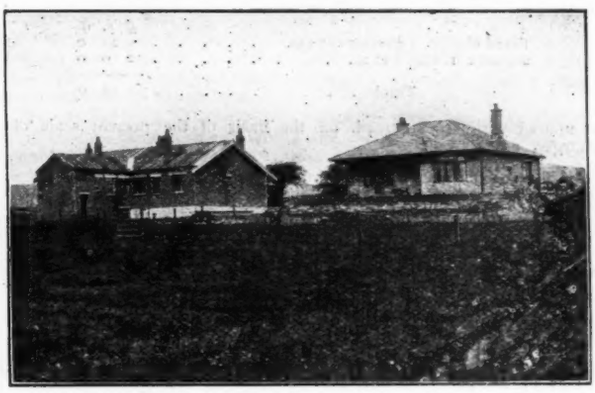
Size of house	4 rooms
Appliances Installed—	
1 gas cooker	
1 gas fire	
1 gas iron	
Size of service	1 in.
Consumption per annum	84,600 c.ft.
Standard requirements	9,000 c.ft.
Fixed charges	9s. 9d. per qr.

7.—GROUP B. DIVISION 3.

Size of house	6 rooms
Appliances Installed—	
2 gas fires	
1 cooker	
1 gas copper	
Size of service	¾ in.
Consumption per annum	50,000 c.ft.
Standard requirements	11,000 c.ft.
Fixed charge	11s. 11d. per qr.

6.—GROUP B. DIVISION 1.

Size of house	3 rooms
Appliances Installed—	
1 gas cooker	
1 gas fire	
1 gas copper	
1 gas iron	
Size of service	¾ in.
Consumption per annum	128,000 c.ft.
Standard requirements	9,000 c.ft.
Fixed charge	9s. 9d. per qr.



8.—GROUP B. DIVISION 5.

Size of house	6 rooms
Appliances Installed—	
2 fires	
1 gas cooker	
1 gas copper	
Size of service	1 in.
Consumption per annum	*
Standard requirements	13,000 c.ft.
Fixed charge	14s. 1d. per qr.

* Houses in course of erection.

CLASSIFICATION No. 4.

The rate under this contract is available only to a customer whose demand between the hours of 10 a.m. and 2 p.m. on Thanksgiving Day, Christmas Day, New Year's Day, and Sundays during the period from Nov. 15 to March 15 following does not exceed 10 p.ct. of the maximum demand as defined.

DEMAND CHARGE.

	Total per Annum.	Corresponding Figure for Halifax £2 per 20 C.Ft. of the Demand.
	£ s.	£
5 c. per c.ft. for the first 100 c.ft. of the max. demand	12 10 ..	10
4 c. per c.ft. for the next 400 c.ft. of the max. demand	40 0 ..	40
3 c. per c.ft. in excess of the max. demand over 500 c.ft. in any month	1s. 6d. ..	2s.

COMMODITY CHARGE.

	s. d.
70 c. per 1000 c.ft. for the first 100,000 c.ft. consumed in any month	2 11
60 c. per 1000 c.ft. for the next 400,000 c.ft. consumed in any month	2 6
55 c. per 1000 c.ft. for the next 500,000 c.ft. consumed in any month	2 3½
50 c. per 1000 c.ft. for the next 1,000,000 c.ft. consumed in any month	2 1
45 c. per 1000 c.ft. for the excess consumption in the month over 2,000,000 c.ft.	1 10½

Plus an oil price clause.

RATES FOR GAS—HALIFAX, YORKSHIRE.

DOMESTIC—
Demand Charge—per quarter—
9s. 9d. ($2.34 c.) for the first 240 sq. ft. or less of floor space.
1s. 1d. (26 c.) for each additional 26·5 sq. ft. or less.
Commodity Charge—
2s. (48 c.) per 1000 c.ft.

ALTERNATE RATE (Lighting)—
3s. 11d. (94 c.) per 1000 c.ft.

ALTERNATE RATE (Non-Lighting)—
3s. 5d. (82 c.) per 1000 c.ft.
Note.—There is no fixed charge or minimum payment in these alternative scales.

PREPAYMENT METERS—
1d. (2 c.) for 20 c.ft.
Note.—All of the above charges are made quarterly.

COMMERCIAL AND INDUSTRIAL (Heat, Light, and Power)—
Fixed Charge—per annum—
£2 ($9.60 c.) per 20 c.ft. in the hourly demand.
Commodity Charge—per *annum*—

2s.	(48 c.)	per 1000 c.ft.	for the first	1,000,000	c.ft.
1s. 9d.	(42 c.)	,, ,, ,,	,, next	1,000,000	,,
1s. 6d.	(36 c.)	,, ,, ,,	,, next	1,000,000	,,
1s. 3d.	(30 c.)	,, ,, ,,	all over	3,000,000	,,

Alternate Rate (Lighting)—per *quarter*—

3s. 11d.	(94 c.)	per 1000 c.ft.	for the first	100,000	c.ft.
3s. 10d.	(92 c.)	,, ,, ,,	,, next	100,000	,,
3s. 9d.	(90 c.)	,, ,, ,,	,, next	100,000	,,
3s. 8d.	(88 c.)	,, ,, ,,	,, next	100,000	,,
3s. 7d.	(86 c.)	,, ,, ,,	,, next	100,000	,,
3s. 5d.	(82 c.)	,, ,, ,,	all over	500,000	,,

Alternate Rate (Heat and Power)—per *quarter*—

3s. 5d.	(82 c.)	per 1000 c.ft.	for the first	1,000,000	c.ft.
2s. 11d.	(70 c.)	,, ,, ,,	,, next	1,000,000	,,
2s. 5d.	(58 c.)	,, ,, ,,	all over	2,000,000	,,

Note.—All accounts are rendered quarterly

HIGH-PRESSURE GAS LIGHTING.

This class of supply is available in certain areas of the borough at the following rates, which include the loan of lamps and fixing the same, together with all maintenance charges—viz., cleaning, lighting, extinguishing, the renewal of mantles and globes as required, and the supply of gas.

Lighting Capacity. Candle-Power.	Inclusive Charge per Annum for All Gas and All Service and Maintenance.
500	£3 0s. ($14 40 c.)
1000	£4 12s. ($22 8 c.)
1500	£6 3s. ($29 52 c.)

The lamps are lighted at dusk and extinguished at the recognized shop closing hours now in force—a total of 404 hours for the year. For any extra hours the charge will be 1d. (2 c.) per lamp per hour.

COPY OF CIRCULAR LETTER SENT TO CONSUMERS.

Halifax Corporation Gas Department,
Mulcture Hall Road.

DEAR SIR(S),

STANDARD REQUIREMENT OF THE PREMISES.

Referring to Our Inspector's Visit.

Your standard requirement of gas would be 12,000 c.ft. per annum, and the fixed charge would therefore be 13s. per quarter.

Assuming that the consumption of gas would be the same as for the year ended March, 1926, your account for the year would be as follows:

	£	s.	d.
Fixed charge, 4 quarters at 13s.	2	12	0
20,000 c.ft. of gas at 2s.	2	0	0
Total	£4	12	0

compared with £3 14s. 4d. on the basis of the present scale of charges, as follows:

	£	s.	d.
12,000 c.ft. of gas at 3s. 11d.	2	7	0
8,000 c.ft. of gas at 3s. 5d.	1	7	4
Total	£3	14	4

If you wish to be enrolled under this scheme will you please call at the Gas Showrooms, Waterhouse Street, and sign the necessary agreement.

Yours faithfully,

GAS ENGINEER AND MANAGER.

Gas at 2s. per 1000 c.ft. *plus* the fixed charge, in some cases amounts to more than the ordinary rate, but when the consumption of gas is above the average consumers should adopt the new scheme.

COPY OF CIRCULAR LETTER SENT TO CONSUMERS.

Halifax Corporation Gas Department,
Mulcture Hall Road.

DEAR SIR(S),

STANDARD REQUIREMENT OF THE PREMISES.

Referring to Our Inspector's Visit.

Your standard requ'rement of gas would be 11,000 c.ft. per annum, and the fixed charge would therefore be 11s. 11d. per quarter.

Assuming that the consumption of gas woulu be the same as for the year ended March, 1926, your account for the year would be as follows:

	£	s.	d.
Fixed charge, 4 quarters at 11s. 11d.	2	7	8
43,000 c.ft. of gas at 2s.	4	6	0
Total	£6	13	8

compared with £7 12s. 5d. on the basis of the present scale of charges as follows:

	£	s.	d.
11,000 c.ft. of gas at 3s. 11d.	2	3	1
32,000 c.ft. of gas at 3s. 5d.	5	9	4
Total	£7	12	5

If you wish to be enrolled under this scheme will you please call at the Gas Showrooms, Waterhouse Street, and sign the necessary agreement.

Yours faithfully,

GAS ENGINEER AND MANAGER.

Discussion.

Mr. P. E. BROWNE (Brighton): I should like first of all to pay my tribute of thanks to Mr. J. W. McLusky for his paper. I admire his courage in tackling the after-care of appliances. In Brighton we have some experience of this, so that the paper is of great interest to me personally. We have been working such a system for 33 months. When we started we thought it was a pretty severe nettle to grasp, but when Mr. McLusky talks of 300,000 consumers, I take off my hat to him for his courage. We have only 50,000 consumers. I am sure he is right; it is no use our being content to live in the complacent state of selling gas to the consumer at the point of the meter, and leaving it at that. Consumers' appliances must give satisfaction, or they are of no use in the long run to the gas undertaking concerned. The consumers will not grumble to us, but of us. They will not bring their troubles direct to the undertaking, so that we lose them before we have a real knowledge of their dissatisfaction. This was our real reason for instituting what we term universal maintenance service at Brighton; and we have therefore looked upon it as an insurance premium. By that, I would say that we admit to ourselves, if not in public, that gas lighting installations are difficult to obtain in the better class dwellings, and therefore we are impelled—compelled in our judgment—to seek to retain those we have. The artisan customer is the backbone of our business in Brighton; and we maintain his appliances, and more especially his lighting burners, against the day when the Electricity Department will seek to give assisted wiring and electric light fitting, and supply through slot meters in a similar manner to that in which the Gas Company now supplies gas.

I would like to ask Mr. McLusky if his men are really performing in the domestic area 5000 visits per man per annum. I have allowed 52 Sundays off his 365 days, and also 5 Bank holidays which obtain in Scotland, and also each man six working days' holiday, so that the total working days will be 300, inclusive of Saturdays. I have thrown that in; and I find that each man averages 17 calls per man per diem. If his list of duties, which is a very severe one, is carried out, he is only allowed half an hour per visit, including his walking time and his yard time. I should like to ask Mr. McLusky's opinion on this, and to know what the actual experience has been. With regard to the maintenance costs, the average cost per appliance is given as 7·39d.; and this total includes 5·11d. for labour, 1·06d. for material, and 1·22d. for oncost. Brighton's figure against this is 6·88d.; but I have not included material, and I do not follow what is meant by "material" in the paper. Do you provide new mantles entirely free for lighting fittings? We charge for them entirely. We supply material in the case of hire appliances only, free of charge; but in the case of all other fittings and privately owned appliances, material is paid for. I was rather intrigued to find that Glasgow has 5·28 units per meter under maintenance per annum, against Brighton's 4·026; and yet we in Brighton have a higher charge for maintenance per appliance, if we include material. The cost per meter connection in Glasgow, however, is 3s. 10·97d., against Brighton's figure of 2s. 3·71d. As a matter of fact, I cannot make the Glasgow figures come to 3s. 10·97d. I make it 3s. 3·019d. There is thus a difference of 7·7d. Mr McLusky has an asterisk against his figure, and he states: "This is the average cost per meter, and all appliances served by same." I hope Mr. McLusky will be able to elucidate this little mystery for me. I was therefore rather worried when I worked out the cost per therm and per 1000 c.ft. for Brighton. I am not worried now, I am rather happy about it—because I found that, instead of the cost being 0·236d. per therm, or 1·11d. per 1000 c.ft., for the year ended June 30, 1926, the figures were 0·11d. and 0·58d. respectively. I find that that is brought about by the fact that, though we have roughly 50,000 consumers, our gas made in 1926 was 2142 million c.ft., against Glasgow's 8599 million c.ft. for about 300,000 consumers. This, I think, is because Glasgow is nearer the coal mines, and gas for domestic use—anyhow for heating—is not employed to the same extent up North as it is down South.

I confess that the paper by Mr. W. B. McLusky, of Halifax, takes my breath away. I congratulate him on having one of the smallest householders who uses 82,000 c.ft. per annum through a 1-in. service. I wish we had this sort of thing in Brighton. Mr. McLusky goes on to show, later in the paper, that the Halifax scales are entirely voluntary, and established within the law as it stands. I believe I am right in saying that, in Brighton at any rate, we may not give preferential terms as between consumers who use gas for the same purpose. We can only give a quantitative discount. I do not know whether that is general, but it certainly is the case with our Company. My Chief, perhaps, will tell us whether it is under a Private Act or a Public Act. I understand that it is a Private Act. We can get round it, of course. Then the paper says that a perfect understanding of these figures would remove misunderstanding between consumers of the gas undertaking. I am afraid it would be very difficult to make most consumers of gas see the point of that scale. It is all right for the large consumer, I admit, and probably it is all right in a town like Halifax; but in a residential town such as Brighton, where the vast majority of the business is made up of the ordinary domestic consumer, I do not think you could adopt scales of that type at all. I see, also, that the paper states a minimum of 27,000 c.ft. would be the lowest consumption on which the scale rate would pay, and, I take it, be granted. The average gas sold per consumer in Halifax is somewhere near that figure, and so the 10,000 consumers, I should imagine, are getting somewhere near your possibility. Perhaps you will tell us something on that score. In the examples in the paper, some domestic consumers are given which make me envious.

Mr. W. B. MCLUSKY: You believe it?

Mr. BROWNE: Of course. (Laughter.)

Mr. GEORGE EVETTS: My criticism is confined to the second part of the paper. I am sure we all agree that the principle laid down in the scales of charges there is sound—*i.e.*, we first want to see from the customer a payment to reimburse the undertaking for the capital expended and the privilege the consumer has in being able to call upon the gas undertaking; and, secondly, a further payment for the article actually consumed. So far, I think we are all in agreement; but we must remember that even this principle is not necessarily universally accepted in this country. I can quote two branches of a Government Department as a simple example. The Postal Department will carry a letter for 1½d., whether it is a thousand miles or to the house next door. The Telephone Department require a standing charge whether you have one call or a thousand. Therefore you have two opposite commercial principles in two different Government Departments. The author has found his principle successful; and it is not to be wondered at. He is offering a certain element of consumers better terms than they have had before; and it is not surprising that 10,000 out of 25,000 ordinary consumers voluntarily accept something which is going to give them a better bill at the end of the year than was the case before they adopted it. Any system which contains this great advantage will be accepted whether it is a scientifically sound system or not; and it is this aspect of the thing which I should like to discuss with the author for a few moments this afternoon. The author starts on a sound basis. He wants a certain sum of money to pay him certain standing charges which he has to meet whether he sells a large quantity or a small quantity of gas. Then, instead of allocating this according to the demands of the consumers on the undertaking, he allocates it according to the size of the house the consumer lives in. In other words, he says to the consumer: "Look here, my friend, you ought to use so much gas; and I am going to assume, in working out your scale of charges, that you are going to take that amount." I should prefer to see that system based not on what the consumer should take, in the eyes of the undertaking, judged by the class of house, but on how much he is prepared to take according to the size of the service pipe, meter, and appliances that are installed. According to the author's system, you can have two houses next door to one another, of identically the same size, rated at a certain equal fixed charge, though the demand of the one on the undertaking may be ten-fold that of the other. In my humble opinion, this is not a sound method of assessment. Of course, in the author's case it has the saving grace that it is optional, and therefore it is an acceptable scheme to the man who is going to save something by adopting it, and it does not matter to the person who is not going to look at it. The system is, up to a point, unfair in so far as it does not eradicate the present unfair position that there are certain consumers who have to be subsidized by the others. In making the system optional, the author still leaves the unremunerative consumer; and the good consumer has to pay something towards this, though, I admit, not so much as before the system was introduced. In the author's tables there are certain inequalities in certain groups; and this, I maintain, is due to the fact that the basis of allocation on the superficial area of the rooms is unsound. He has consumers (*e*) and (*f*) both in the Domestic Class D. Consumer (*e*) takes 8000 c.ft. per annum; and this consumer shows, if the author's system of allocation is correct, a payment of £1 11s. 4d. per annum—*i.e.*, 8000 c.ft. at 3s. 11d. per 1000 c.ft.—whereas according to the new scale of the author he ought to be paying £4 1s. That is a deficiency of £2 9s. 8d. per annum, if he were paying the correct sum per annum according to the author's scale. Consumer (*f*) takes 11,000 c.ft. per annum, and should pay £3 1s., whereas in fact he pays £2 3s. 1d. That is a deficiency of 18s. 11d. I cannot believe, if the system is accurate, that the difference between an 8000 c.ft. consumer and an 11,000 c.ft. consumer represents a deficiency in the one case of £2 9s. 8d., and of 18s. 11d. in the other. In fact, the figure which the author gives of 10s. 1½d. as the price which the 8000 c.ft. customer should pay, I work out to 5s. 6½d. only; and I cannot think that any scientific method of working-out gas costs would bring out such a difference as I have just mentioned, as between an 8000 c.ft. consumer and an 11,000 c.ft. consumer, calculated on the flat rate. Of course, the standard requirement itself is a complicated figure, because the author tells us that the multiple of 40 was put up, during the war, to 75, and now it is 37½. If a standard requirement is a standard requirement, it ought not to fluctuate over a period of years like that. What the author has to have, of course, is a bigger or a smaller revenue, as the case may be; and he multiplies the floor area by a different number of cubic feet, in order to get the amount of gas the person requires, before making his account; but surely the correct method is to alter the charge for the standard requirement, and not the standard requirement itself. I think the charge for the standard requirement should vary, and not the amount of gas one is expected to take.

Apparent consumers (*d*), (*e*), and (*f*) are all given an option to come into Group A or Group B. Consumer (*d*), if he comes into Group A, pays £14 4s. 8d. per annum. If he comes into Group B, which is the group the author places him in, he pays £10 3s. Either Group A is the correct method of assessment, or Group B is incorrect, because the difference between the two bills is £4 1s. 8d. per annum, and the position is further aggravated by the fact that for every 1000 c.ft. more which the consumer takes in Group A he will pay 3s. 5d., whereas in Group B the figure will be 2s. Therefore, either Group A is unfair to the consumer, or else Group B is giving him gas at a cheaper price than he ought to have it. This again is reflected in (*e*) and (*f*), because if the consumer is in Group A he will pay £1 11s. 4d., while if he is in Group B his annual bill will be £4 1s. If consumer (*f*) were in Group A, his annual bill would be £2 3s. 1d., while if he were in Group B his bill would be £3 1s. I think these anomalies are due to the incorrect basis of assessment under the system—viz., on the floor area instead of on the demand that the consumer is likely to make upon the undertaking. I think that if the matter had been attacked from this point of view, we should have had an equally sound system in principle, but a much more equitable one when we came to work out the actual details.

If you look at the photographs of the houses in the paper, you will find that No. 2 is a six-roomed house, and has two gas fires, one gas cooker, and a gas copper. No. 6 has a gas cooker, a gas fire, a copper, and an iron. Thus, instead of the second gas fire there is an iron, so that for all practical purposes here we have two consumers with an equal demand on the undertaking, and, more than that, with almost equal annual consumption, because No. 2 takes 121,000 c.ft. per annum and No. 6 128,000 c.ft. per annum. Yet, because No. 6 is a three-roomed house, he only pays a fixed charge of 9s. 9d., while the other tenant has to pay 16s. 3d. fixed charge, because he is in a six-roomed house; yet the consumption is the same in both cases. In my opinion these examples of two almost identical consumers prove that the assessment on the floor area is not sound. I have to acknowledge my indebtedness to the author for introducing this subject, which is one on which I personally am very keen; and although these criticisms of mine have been levelled more against the actual method that has been adopted, in putting his principle into operation, I think the author has been justified by the results.

Mr. A. HEWITT (Toronto): No matter what you may think of it to-day, this problem which the author has dealt with in the second part of the paper is one which you will be forced to deal with very soon, whether you want to or not. You will not be able to continue business without some change in the present form of charge to the consumer. In Canada, and in Toronto particularly, with the electrical competition that we have to face, with its service charge system, the gas business would be washed out in a very short time if we had not taken this problem in hand, for this reason. We knew by actual records that under the flat-rate system we were doing business at a loss with 62 p.ct. of our 150,000 consumers, and that the remaining 38 p.ct. were carrying the others. The point was how long they would be satisfied to carry them. Nobody is entitled to something for nothing; and if we do not make the small consumer pay the cost of the service he gets, then the large consumers will go over to the electrical people, and you will then be in the position of having your unprofitable consumers with you always, and no good ones to help pay for them. In Chicago, I know for a fact that at one time they were doing business with 72 p.ct. of the gas consumers at a loss. I got that from the President in Chicago personally. Therefore, I think that this is the most opportune time for a discussion upon this subject. We have seriously to consider some plan, because the time to get a service charge system into operation is when you are going to reduce the price of gas, and not when you are going to increase it. By the very small consumer is not necessarily meant the poor man.

I am only dealing with principles; and I should like to congratulate the author on the thoroughness of the paper. I think it is a very simple proposition put in this way. The commodity charge is clearly and distinctly separate from the consumer charge; the cost of the gas into the holder, and all the items concerned with the manufacture of the gas coming into the commodity charge. You gentlemen know—at least, we do from our standpoint, your circumstances may be different—that it costs quite as much, if not more, to distribute the gas as it does to make it; and if the consumer charge, which begins after the holder and up to the point of the consumer's meter or even the consumer's appliances, is equitably distributed per consumer, then the revenue should be adequate. What in the world has 1000 c.ft. or the therm got to do with the consumer charge? Obviously the only adequate method of charging is to charge the consumer a reasonable sum to represent the interest on capital and other overhead charges according to the individual demands, *plus* the cost of the gas into the holder. In this way the man who takes the largest quantity will get it at the lowest price. I will not deal with the details of the paper; but in Canada before the war we sold gas at 3s. per 1000 c.ft.—it was actually a little less than 3s. We maintained this price during three years of the war, feeling that it was part of our burden, as the gas undertaking, to carry. Then we increased our rates until we got to 5s. per 1000 c.ft. We were going to reduce the price of gas immediately by 10 c. per 1000 c.ft., and we determined upon a service charge of 50 c. per month. Since then we have been able to make two or three reductions in the price of gas, because every consumer is paying his way. We now have individual consumers who pay $50,000 a year for gas, and we have 150,000 meters which show an average consump-

tion of 37,000 c.ft. a year. You never would be able to do that on a flat-rate basis. You will never have a practical basis while you work on a system under which the large consumers have to carry charges which ought to go on to the small consumers who are not profitable.

We had to alter hundreds of thousands of meters when we looked into the stand-by question, because these people took electricity, and merely had the gas in as a stand-by against a failure in the electric light, and they did not return us a cent of revenue. That is not fair. The lighting business in England has been referred to; and I gather that you are losing a good deal of lighting business. In Canada we are losing some, and, like you, we expect to lose more; but the point is: What are we going to do to get something to take its place? In my opinion, if you go to work on the principles laid down in this paper, you will not only hold the business you have got—you will not hold the lighting business—but you will also get new business. I believe that the adoption of the principles laid down in this paper will be one of the greatest steps forward, especially if we use diplomacy in introducing the service charge. In rendering our accounts, we do not show any service charge on the face of it. There are so many cubic feet of gas shown, and the charge is made; but there is a footnote that the charge includes a service charge of 50 c. We also have a little schedule on the bill, which shows that the price of gas for the first 10,000 c.ft. is 85 c., for 90,000 c.ft. it is 80 c., and for over 100,000 c.ft. per annum it is 75 c. At the bottom is a note to say that the service charge is 50 c. per month; but on the face of the bill the service charge is not shown like a sore finger coming up every minute. Nevertheless, it is included in the amount the customer pays, and it is part of the cost of his service.

The PRESIDENT: Mr. Hewitt will have to supply the details of the Toronto system of charging. We should like to have details not only of the charge to the consumer, but also of the manufacturing cost and the costs of distribution. I shall rely upon him to do that immediately he gets back to Toronto.

Mr. HEWITT: I will.

Mr. THOMAS GLOVER (Norwich): I am very grateful myself for these two papers. The maintenance system in Glasgow has been admirably described by one of the distinguished brothers McLusky; and I would also like to say that I thoroughly believe in the importance of the Halifax method of charging. Mr. McLusky, of Halifax, is to be congratulated upon his boldness and ingenuity in devising this scheme. I quite agree with the last speaker that there is no more important subject before the industry just now. We want something to match the telephone system adopted by the electrical people, which is encouraging very successfully the greater use of electricity. I cannot conceive of anything which will do it better, in the case of gas, than a substantial reduction after the service charge has been met; and this is what Mr. McLusky is seeking to do. I want to ask him if he will be good enough to tell us what the effect has been on the 10,000 consumers who have adopted this system. Can he give us a few instances with regard to the increased consumption due to the substantial reduction in the price of gas, after the service charge has been met? With regard to the last speaker, when I was in Toronto I found that the price of electricity was 1¾d. per unit; the electricity being brought from Niagara Falls. Nevertheless, I think they were sending out about six times the quantity of gas per hour that we are in Norwich. I was rather proud of Norwich before I heard of that figure. Our figure is between 300,000 to 400,000 c.ft. per hour at the heaviest peak load; but Toronto is sending out about six times that quantity, in spite of such cheap electricity. I suppose this is partly due to the substantial reduction in the price of gas after the commodity charge has been met. Toronto has succeeded in selling gas very successfully in spite of very cheap electricity, and the fact that there is not a gas light to be found in Toronto. The success of the Company was therefore demonstrated.

The PRESIDENT: I had hoped that circumstances would have given us a longer time for the discussion of this subject. You are probably aware that both the Institution and the industry as a whole attach the greatest importance to the solving of this problem of differential prices for gas, and, coupled with that, securing the goodwill of the consumer. There can be nothing easier than the general application of the service system, which certainly, where it has been put into operation, has been most effective; and it is undoubtedly done at a reasonable cost. I have made the point before, that, having regard to the tendency of gas legislation, it is well to remember that, if service to the consumer means a charge affecting the cost of gas, the same service must be rendered to every consumer. The point has been raised whether the Halifax scheme is within the law. I think it is so absolutely, for the reason that the underlying principle of our legislation, which is a model for public service supply, is that we must treat all consumers in like circumstances alike. Certainly, under the Halifax system, if you can find two people alike, they are treated alike. Therefore, this clearly brings the scheme within legislation as it stands to-day. There are many important things which one would like to say; and you can understand that, having the honour to preside over a composite Committee dealing with differential charges, it would have been very helpful to me, in assisting the Committee, if there had been a lengthy discussion this afternoon. I would therefore beg all my colleagues present who have any thoughts or practice bearing on this subject of differential prices, to remember that it will assist the industry if they will let us have their opinions in writing.

Mr. J. W. MCLUSKY (Glasgow), replying to the discussion, said: Mr. Browne from Brighton gave us some encouragement, and asked one or two questions. I should have been surprised if Brighton and Glasgow had produced the same costs for maintenance, because of the different nature of the two places. I have been to Brighton once or twice, and I only know it in a general way, as a visitor, but I feel sure that it is an entirely different place from Glasgow, where we have at least 40,000 single apartments. When I say this, you will probably tell me that it reduces the cost per house for appliances. It increases the work, however. The work is enormous in these places, because of the fact that property owners have not any money. They cannot allow the house factors any money; and the Gas Department have been criticized for doing a great deal of work which the property owners might have been expected to do. But we had to do it, if we were going to sell gas. I said in Liverpool last year that if it cost 3d., I would ask the Corporation to do it; and if it cost only a penny, I would do it. Therefore, this question of costs is reflected in my cost sheet in the paper, because it includes what we call the first service, or plough work. We had a good deal of fitting work to do which was charged to maintenance, such as the re-hanging of pipes, and so on. This, of course, we do not expect to be repeated; but there is a lot of work included in those figures, such as the provision of hold-fasts, white lead, jointing material, &c., which we did not charge the consumer. The calls per man per day are affected by the assumption that this is how we expect the scheme to work when we get set. It is not fair to claim that they would do all the early work again; and this would affect the number of calls later. At present a man could not do 17 calls per day. On the first journeys he averaged an hour per house. On the second journey he might average half-an-hour per house. Of course, at some houses, he would be a quarter of an hour, and at others 1½ hours. It all depends on the quantity of work to be done, and a great deal depends on the type of housewife—what the housewife will put up with. What I want to impress upon those present is that in the present state of the gas industry we must go in for maintenance on these lines. You may flatter yourselves you do not need it; but that does not affect me. If this maintenance is going to cost anything between 1d. and 3d., I say it is high time it was being done. Did you read the other day of the coming programme of the Electrical Development Association? They know how many burners have been put in recently, and they have set themselves a very formidable task for the coming season. Who is going to stand up to this competition? It is the maintenance man. You can prevent the good-class customer from throwing out gas for lighting, by showing him the best type of burner, and proving to him that gas is a hygienic method of lighting and heating. We do not want, however, to follow the example I saw last night in the Hotel Cecil, where in one of the rooms was a gas fire 40 years old, I should think. You could not see it for cigarette ends and burned matches. That was a nicely furnished sitting room; and a beautiful gas fire ought to be put into it, because the room was beautifully decorated. Yet we have this abortion, dated 1880 or 1888, in one of the main hotels in London. A maintenance scheme would soon have that out.

Mr. W. B. MCLUSKY, also in reply to the discussion, said: I am sorry Mr. Browne of Brighton has misunderstood the paper. The President has already told Mr. Browne that under the general law we must supply everybody in like circumstances on similar terms. The paper shows that the consumers referred to in the paper are not being supplied in the same circumstances, and therefore we are justified in making the charge different. Where the circumstances are the same, the consumer is charged the same.

Mr. BROWNE: I thought it was "like purposes" not "like circumstances."

Mr. MCLUSKY: I cannot realize that anyone like Mr. Browne does not understand the paper. It is so simple. (Loud laughter.) I have been at this for only 25 years; and when Mr. Browne has been at it for 25 years, he will understand it as well as I do. (Renewed laughter.) With regard to Mr. Evetts' remarks, I am not going to tackle Mr. Evetts. (Laughter.) This is really his job; he should have been reading the paper. However, I was first with this system; and those who were opposing me twenty years ago are now coming to shake hands with me. We are all in this job; and the reason you are not supporting me to-day is because you have not read the paper. (Laughter.) When you have read the paper, and have understood it, you will want this scheme or some other scheme. Let me say to Mr. Evetts that any generally accepted scheme will be acceptable to the Deputy Mayor of Halifax, and what he says goes. (Loud laughter.) Mr. Evetts has complained about the floor area being adopted as the basis; but the floor area is a good standard, because if a person has a floor which measures 10 ft. by 10 ft.—I see Mr. Evetts shaking his head against me, but never mind—he will take 3750 c.ft. of gas per annum to light it properly, as it ought to be lighted; and we have provided a supply of gas to light it properly. If that consumer has to

pay the lighting rate for that quantity of gas, I say he is entitled to get any gas he uses in excess of that quantity at the non-lighting rate. This saves putting in another meter.

Mr. Evetts said the floor area is not scientific; but I think it is. We have based our lighting calculations upon it from the beginning. You will never be able to ascertain the variations between one house and another if you take the bore of the service pipe; that goes without saying. Look at the deviations we have. There are sixteen listed in the paper; and there are more than 38 different sizes of houses registered in our books. You have the case of a consumer (*e*) who is using 8000 c.ft. of gas per annum. That consumer actually lives in a "half villa," and the other half is occupied by customer (*c*) who uses 220,000 c.ft. of gas through the same size service pipe and meter, and who has the same floor area. The fixed charge in the two cases is the same—viz., £3 5s. I think I have satisfied you that consumers (*c*) and (*e*) live in "half villas," and that one uses 8000 c.ft. per annum, the other 220,000 c.ft. per annum. The one who uses 8000 c.ft. is evidently satisfied, and we must be satisfied with 3s. 11d. until we have rate reform. Mr. Evetts said that all who would gain by this system would naturally come in. That is perfectly right. All who would gain, or most of those who would gain, have come in. I wonder if I could explain to Mr. Evetts the difficulty with regard to the fixed charge. In Halifax the fixed charge is high, as you will see from the paper—viz., £2 8s. 7¾d. per consumer per annum. In addition, we have to pay a sum which is equal, on the average, to 50 p.ct. of the interest and fixed charges, as a gift towards the relief of rates; and this makes our fixed charges inordinately high. If you take town B in the table, the gas there is cheap not because it costs less to manufacture gas in that town, but because there is no capital on the undertaking, and they have money in the bank. The fixed charge per consumer in that case is only 19s. 8¾d.; and this does not include interest and sinking fund charges, because there are none. It only includes distribution charges; and here is a case where Mr. Evetts' proposal would apply. Mr. Evetts thinks our fixed charges are too high, but he would be satisfied with the fixed charge if we could have every town as in the case of town B, because it is very low as regards the fixed charge. Mr. Evetts' next question was why we varied the multiple. That was done for a very good Scotch reason. It was going to cost us £5000 in the first year when we had the multiple of 40; and so we made the multiple 75 in order to conserve the revenue. We could not afford to drop £5000 in one year, because, as Mr. Evetts said, all those who would gain by the scheme would come in, and we should have lost about £10,000 in one year. Therefore, we made the multiple 75 for a year or two until we had got the scheme going, and then we halved the figure, and made it 37½. The correct multiple should be 40; but owing to the manner in which our books were arranged, it was easier to have the 75 than to have a fresh number which would have given us a vulgar fraction. Mr. Hewitt agrees with everything; and I am very glad, because he has had experience. Mr. Hewitt and I are the only two people who have had experience of this; and we agree. (Laughter.) The President has whispered to me that Mr. Hewitt's system is not the same as mine. (Laughter.) I will not argue with the President. Mr. Hewitt said he sold a certain amount of gas at so much, then the next larger quantity was a little bit less, and the next a little bit less still, and so on. That system has been in operation in Perth for 21 years.

The PRESIDENT: I will talk to you on the Committee. (Laughter.)

Mr. MCLUSKY: I am very proud to see the Lord Mayor of Norwich here, and extremely pleased that he has spoken on the paper. He asked me what is the increased business as the result of this scheme. Every person who has adopted this scheme has added 17,500 c.ft. per annum to his gas bill. The average consumption in Halifax before this scheme was far and away below 25,000 c.ft. It has been a very good increase.

The PRESIDENT: Mr. McLusky is a member of the Committee I just referred to; and he works hard to convince the members of that Committee that the Halifax system is the correct one. Thus there is every chance of its being accepted by the Committee one of these days.

BRADDOCK'S "SLOT" METER,

The UNIVERSAL

Self-contained Change Plate

PREPAYMENT DRY METER,

is second to none.

NO CHANGE WHEEL.

Positive Gearing. Large Cash Box. Strongly Made.
Attachment Detachable. Operated from the Front.
Range from 4 c.ft. to 50 c.ft. per penny, or equivalent quantities for other coins.

The Prepayment Valve Box is Outside the Top of Meter

J. & J. BRADDOCK (BRANCH OF METERS LIMITED), **Globe Meter Works, OLDHAM.**

Telegrams—"BRADDOCK, OLDHAM." Telephone No. 815.

AND 45 & 47, WESTMINSTER BRIDGE ROAD, LONDON, S.E. 1.

Telegrams—"METRIQUE, LAMB LONDON." Telephone No. 2412 HOP.

INSTITUTION GAS RESEARCH FELLOWSHIP, 1926.

INFLUENCE OF THE ASH CONSTITUENTS IN THE CARBONIZATION AND GASIFICATION OF COAL.

Part II.—GASIFICATION OF SPECIAL COKES IN STEAM.

By C. B. Marson, Ph.D., M.Sc., A.I.C. (Gas Research Fellow), and J. W. Cobb, C.B.E., B.Sc., F.I.C. (Livesey Professor).

INTRODUCTION AND SUMMARY.

In the report of the Gas Research Fellowship, 1924, the results were given of gasifying an ordinary coke in steam, with special reference to the alteration in the composition of the gas which followed upon the use of gradually increased rates of gasification. In 1925, the corresponding report dealt with the preparation and preliminary examination of special cokes which had been made so as to study the influence of the ash constituents of coal on its behaviour. Some of these constituents were there shown to exercise a remarkable influence on the nature of the cokes obtained, and on the nitrogen and sulphur compounds, to which particular attention was paid. During the past twelve months this study has been extended to the behaviour of these special cokes during their gasification, more particularly their gasification in steam, and the results obtained are now reported. They demonstrate in unmistakable fashion the influence which the inorganic constituents may exercise in this process.

The method of investigation followed was to take the "pure" coke of very low ash content (1·3 p.ct.) with no added constituent, to gasify it in steam, and to note the results obtained as the rate of steam supply was increased, particularly as regards the composition of the gas and the steam undecomposed, and the value of the ratio $\frac{(CO)(H_2O)}{(CO_2)(H_2)}$ as indicating how far equilibrium was attained in the gas stream. Similar experiments were then made with each of the special cokes in turn. It may be recalled that the special cokes were made by 5 p.ct. additions of such oxides as silica, alumina, lime, and ferric oxide, and of equivalent quantities of calcium carbonate and sodium carbonate to the original coal, so that in each case the particular oxide might be regarded as present in dominating quantity. The results are detailed in the tables given below. It is plain from these that certain constituents, such as silica, alumina (also fireclay), are of little importance in this respect, but that lime, ferric oxide, and sodium carbonate in increasing degree influence the results in a remarkable manner, giving a much higher steam decomposition with lower CO_2 in the gas for the same rate of steam supply. Thus with a steam supply of, approximately, 10 litres per hour, the percentages of steam decomposition were 61 for "pure" coke, and 82, 91, and 98 for the calcium oxide, iron oxide, and sodium carbonate cokes respectively, while the corresponding percentages of CO_2 in the water gas made were 9·2, 5·4, 2·6, and 0·4 respectively. The extreme case was that of the sodium carbonate coke, where the remarkable lowness of the CO_2 figure would suggest that there had been not only attainment of the water gas equilibrium among CO, CO_2, H_2O, and H_2, but that, as nearly as could be gauged, from the extremely low figures, equilibrium was attained also in the C, CO, CO_2 system. The difference in the behaviour of the cokes may be due to the specific catalytic chemical activities of the added inorganic constituents, or may be explained by the previous action during carbonization of these constituents in modifying the physical characters of the coke which are known to be different from those of the "pure" coke, as was noted in the last report. The accompanying photographs would suggest, for example, that the micro-structure of the iron oxide and sodium carbonate cokes is very highly porous. It would be possible, however, to separate the chemical catalytic effect from the physical effect on coke structure of the added constituents by examining the action in steam of the special cokes from which the added constituent had been extracted by chemical means, or by impregnating the "pure" coke with the added constituent, and then testing it in steam. Both these methods are being tried, and the results obtained by the latter method are given in the Supplement to this report. The experimental evidence indicates that the increased reactivity of the special cokes so tested is, in the main, due to the specific catalytic effect of the added compound and not to the alteration in physical structure on carbonization resulting from the addition.

The question arises whether a coke which is known to be highly reactive with steam is also more reactive with carbon dioxide and air, and preliminary experiments carried out for us by Mr. W. R. Branson to ascertain this are in progress. As an example of results so obtained, Table 9 may be consulted, where it is seen that the influence of the additions is again of a most pronounced order; percentages of CO, found after passing CO_2 at the same rate through different cokes, being 6·6, 29·9, 45·6, and 89·0 for the "pure" coke, iron oxide coke, calcium oxide coke, and sodium carbonate coke respectively, while the enhanced reactivity is also strikingly displayed by the figure for grammes gasified per hour which is more than twenty times as great for the sodium carbonate coke as for the "pure" coke.

These observations are interesting theoretically, and may have numerous industrial applications in connection with such processes as water gas manufacture, the generation of hydrogen, blast furnace work, and the combustion of solid fuels in air or oxygen.

It is advisable to settle, as soon as possible, one or two important points in this connection; and experiments are on the way, aimed at answering the questions as to how far smaller additions than those already made will influence reactivity, and how far the effect is modified if the additions are made to coal of a higher and more normal ash content.

Results already obtained are reported in the Supplement. They indicate that smaller additions were effective, even in some cases when the physical structure of the coke had not apparently been appreciably modified. It was established that a coke in which the ash content had been raised by the addition of more of the same ash, was rendered more reactive thereby.

It must be pointed out, as likely to be of primary importance, that intimate contact of the ash constituent with the coal—that is, thorough distribution of the ash through the coal—had been secured in all these experiments by grinding and mixing before carbonization.

EXPERIMENTAL.

PREPARATION OF COKES.

Five per cent. additions of such oxides as silica, alumina, lime, and ferric oxide, and of equivalent quantities of calcium carbonate and sodium carbonate, were made to separate portions of a coal containing originally less than 1 p.ct. of ash. The coal mixtures were carbonized in small fireclay retorts by the method described in Part 1 of this paper. A quantity of the untreated coal was also carbonized in the same way. The composition and description of these cokes have already been given.

Another portion of the coal, to which 5 p.ct. of raw unburnt fireclay had been added, was also carbonized, because, though coal ash does contain free, uncombined silica, and perhaps alumina, the commonest mode of occurrence of these substances is as shale or clay. The analysis of the added fireclay was:—

	P.Ct.
Loss on ignition	9·36
SiO_2	63·48
Al_2O_3	22·39
TiO_2	1·10
Fe_2O_3	1·33
CaO	0·70
MgO	0·52
Na_2O	0·88
K_2O	0·47

All cokes were prepared at a temperature of 800° C., the total carbonizing period being six hours.

The proximate analyses of the prepared cokes, together with the coke yields (the latter calculated to an ash-free basis) are shown in Table 1. It should be noted that in the calculation of the coke yields no account has been taken of any change which might have occurred in the composition of the added compound during carbonization.

TABLE NO. 1.—*Proximate Analyses of Prepared Cokes and Coke Yields.*

Description.	Coke Yield.*	Proximate Analysis.			
		Loss at 105° C.	Vol. Matter.	Ash.	Fixed Carbon
	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.
"Pure" coke	66·2	1·6	3 0	1·3	94·1
Silica coke	66·1	2·0	2 3	7·2	88·5
Alumina coke	65·9	1·6	1 8	8·1	88 5
Iron oxide coke	67·4	2·5	2 9	7·9	86·7
Calcium carbonate coke . .	66·5	1·8	4·1	9·7	84·4
Calcium oxide coke . . .	65·1	2·8	3·4	8·5	85·3
Sodium carbonate coke . .	61·7	1·3	5·0	12·8	80 9
Fireclay coke	66·1	1·1	2·2	8·7	89 0

* Ash-free basis

DESCRIPTION OF APPARATUS AND METHOD OF WORKING.

In order to correlate our results with those given in the Gas Research Fellowship Report of 1924, we have adopted substantially the same experimental methods. The apparatus is almost identical, and the results obtained are given in a similar form. A diagram showing part of the apparatus and a photograph of the whole of it is given in fig. 1.

Purified nitrogen, saturated with steam at a known and accurately controlled temperature was passed over a column of coke (7 cms. long, 2·2 cms. diameter), enclosed in a Morgan reaction tube and packed into position with silica blocks. Prior to each experiment air was removed by evacuation and subsequent replacement with nitrogen.

All the cokes under examination were crushed, and material passing through a sieve of $\frac{1}{5}$ in. aperture, but retained on a sieve of $\frac{1}{8}$ in. aperture, was employed (after drying at 105° C.) and, unless otherwise stated, 10 grammes of coke were used for each experiment.

All experiments were carried out at a temperature of 1000° C.

The gasification products were collected, and estimated as follows:

(*a*) Undecomposed steam gravimetrically by absorption with calcium chloride.

(*b*) Carbon dioxide and hydrogen sulphide gravimetrically, by soda lime, the amount of the latter being estimated afterwards, and its weight deducted from the gross increase in weight.

(*c*) Carbon monoxide, hydrogen, and methane volumetrically by analyses made with the modified Bone and Wheeler apparatus.

After each experiment the apparatus was swept with dry nitrogen for 30 minutes.

METHOD OF REPORTING RESULTS.

All gas volumes are corrected to N.T.P. and calculated as hourly rates. The rate of steam supply was estimated by weighing the saturator before and after each experiment. As a check, the value ($H_2 + H_2O$) is also recorded in the tables—*i.e.*, the volume of hydrogen produced *plus* the volume of undecomposed steam. If all the hydrogen were obtained solely from the decomposition of the steam, this value ($H_2 + H_2O$) should be identical with the amount of steam supplied as measured by the loss in weight of the saturator. Furthermore, if the only reactions occurring were

(1) $C + H_2O \rightarrow CO + H_2$
(2) $C + 2H_2O \rightarrow CO_2 + 2H_2$

it is plain that the volume of hydrogen produced would be equal to ($CO + 2CO_2$). The value ($CO + CO_2$) indicates the rate of gasification of the carbon.

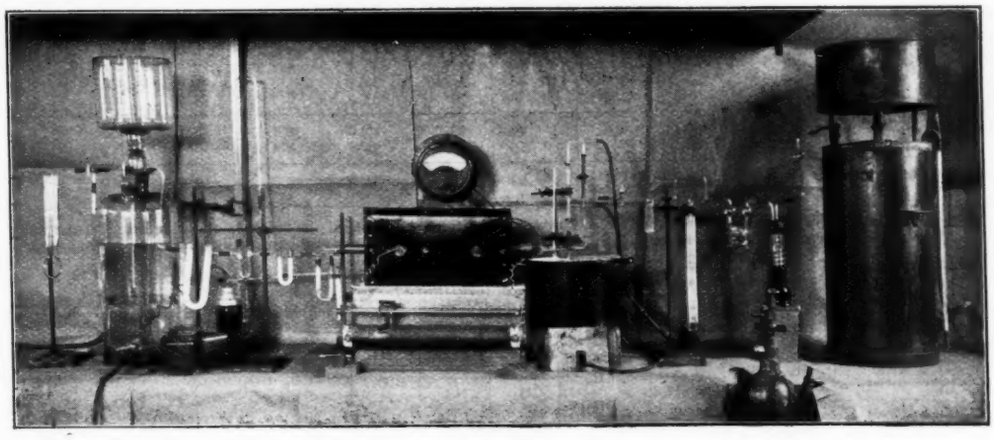
The volume of dry water gas recorded does not include that of the methane, which is small in amount and is given in the dry gas compositions.

GASIFICATION OF "PURE" COKE, SILICA, ALUMINA AND FIRECLAY COKES.

(*Series Nos.* I., II., III., *and* IV.)

The results of gasifying these cokes are given in Tables 2 and 2 (continued), and those for "pure" coke are represented graphically in fig. 2.

In the "pure" coke series, as the steam velocity was increased from 1 to 21 litres per hour, the amount of steam decomposed fell from 77·9 to 50·5 p.ct., and the carbon



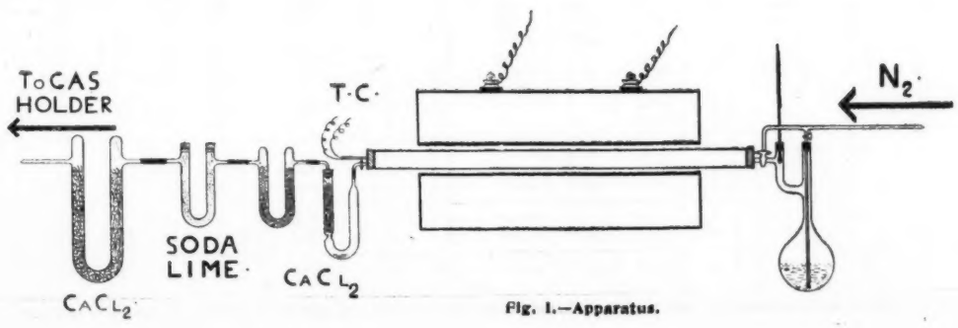


Fig. 1.—Apparatus.

dioxide in the gas rose from 4·6 to 9·9 p.ct. Hahn's equilibrium value for the expression $\frac{(CO)\ (H_2O)}{(CO_2)\ (H_2)}$, as read from his graph of experimental results, is 1·62 for 1000°C.; and if we accept this value it will be seen that the gaseous reaction products did not attain equilibrium in any one experiment.

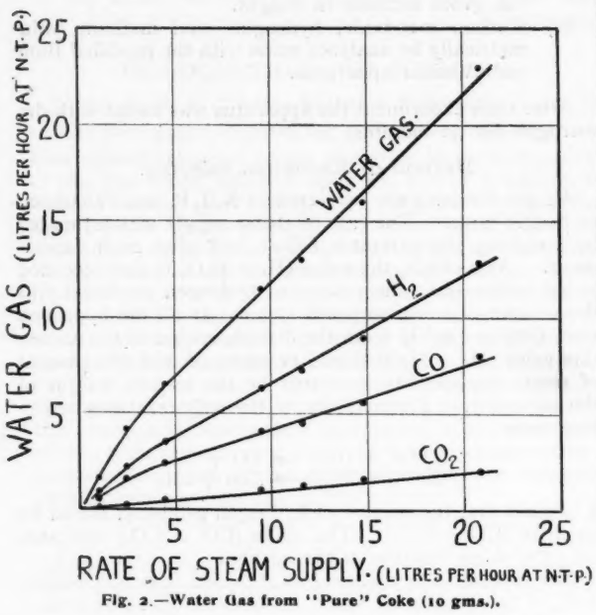


Fig. 2.—Water Gas from "Pure" Coke (10 gms.).

The silica, alumina, and fireclay cokes gave results very similar to those obtained with "pure" coke.

It was considered desirable to ensure that experimental results could be repeated; and with this in view, after four different types of coke had been examined (including two highly reactive varieties), a check experiment with "pure" coke was carried out, with satisfactory results. The alumina coke experiments, which were carried out towards the end of the work described, served as further confirmation.

Gasification of Iron Oxide Coke.

(*Series No.* V.)

The results of gasifying the iron oxide coke are given in Tables 3 and 3 (continued), and represented graphically in fig. 3. These results were markedly different from those obtained with the "pure" coke. As the steam velocity was increased, the amount of steam decomposed fell from 95 to 84 p.ct., and the carbon dioxide in the gas rose from 1·5 to 5 p.ct. It is noteworthy that in experiments 18 to 22, the value for the expression $\frac{(CO)\ (H_2O)}{(CO_2)\ (H_2)}$ was constant (approximately 1·4), indicating that equilibrium in the gasification products had been obtained.

Experimental difficulties prevented the use of steam velocities greater than 22 litres per hour; but as it was desirable to know the nature of the reaction when a large excess of steam was present, experiment 23 was made using 5 grammes of coke (instead of the standard 10), and a steam velocity of 18·8 litres per hour, and experiment 24 using 2·5 grammes of coke and a steam velocity of 15·5 litres per hour. The rates in these experiments, on a 10 gramme basis, would be approximately 18·8 × 2 = 37·6 litres per hour and 15·5 × 4 = 62 litres

Table No. 2.

Description.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming. Hrs. Mins.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified. Grammes per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.*
"Pure" coke (10 grammes) .	I.	1	1·0	3 30	77·9	16·1	0·46	1·6	1·6	3·4
" " " " " .		2	2·5	1 40	77·0	19·2	1·15	4·1	1·6	1·7
" " " " " .		3	4·5	1 15	69·5	21·9	1·75	6·5	1·4	1·2
" " " " " .		4	9·6	1 0	61·7	31·0	3·1	11·5	1·2	0·82
" " " " " .		5	11·7	0 45	56·4	26·9	3·6	13·0	1·1	0·73
" " " " " .		6	14·8	0 45	57·1	32·4	4·3	16·0	1·1	0·61
" " " " " .		7	20·9	0 30	50·5	27·5	5·5	22·9	1·1	0·43
Silica coke (10 grammes) . .	II.	8	1·0	3 30	77·7	17·0	0·48	1·6	1·6	3·5
" " " " . .		9	2·7	1 40	71·5	19·6	1·2	4·0	1·5	1·7
" " " " . .		10	4·5	1 15	67·0	21·8	1·7	6·0	1·3	1·3
" " " " . .		11	11·0	0 50	57·3	28·2	3·4	12·3	1·1	0·74
" " " " . .		12	13·7	0 45	58·6	32·3	4·3	15·6	1·1	0·64
" " " " . .		13	22·3	0 30	57·1	33·7	6·7	24·7	1·1	0·42
Alumina coke (10 grammes) .	III.	14	2·6	1 40	77·7	19 0	1·1	4·1	1·6	1·7
" " " " .		15	10·4	0 55	62·0	31·0	3·4	12·5	1·2	0·79
Fireclay coke (10 grammes) .	IV.	16	11·1	0 50	49·6	23·8	2·9	10·9	1·0	0·75

* The time of contact in this and the following tables was calculated from the mean of the volumes of gas entering (steam and nitrogen) and the gas leaving (water gas, water vapour, and nitrogen). Either volume could be used alone without serious error.

Table No. 2 (*continued*).

Experiment No. (See Table 2).	Litres per Hour at N.T.P. of Wet Gas Constituents.								$\frac{CO}{2CO_2}$	$\frac{CO}{CO+CO_2}$	$\frac{(CO)\ (H_2O)}{(CO_2)\ (H_2)}$*	Dry Gas Compositions. Percentages by Volume.			
	CO_2.	CO.	$CO + CO_2$.	H_2.	H_2O.	$H_2 + H_2O$.	CH_4.	N_2.				CO.	CO_2.	H_2.	CH_4.
1	0·078	0·66	0·74	0·89	0·21	1·1	0·028	2·9	0·82	0·892	2·00	39·9	4·7	53·7	1·7
2	0·22	1·62	1·84	2·25	0·59	2·8	0·096	5·2	2·06	0·880	1·93	38·7	5·2	53·8	2·3
3	0·51	2·43	2·94	3·55	1·38	4·9	0·059	5·3	3·45	0·826	1·85	37·1	7·8	54·2	0·9
4	1·06	4·08	5·14	6·32	3·69	10·0	0·096	5·4	6·20	0·793	2·25	35·3	9·2	54·7	0·8
5	1·30	4 45	5·75	7·25	5·08	12·3	0·117	5·1	7·05	0·774	2·40	33·9	9·9	55·3	0·9
6	1·55	5·59	7·14	8·86	6·37	15·2	0·159	5·2	8·69	0·783	2·59	34·6	9·6	54·8	1·0
7	2·00	8·09	10·09	12·85	10·35	23·2	0·226	7·0	12·09	0 802	3·26	34·9	8·6	55·5	1·0
8	0·074	0·66	0·73	0·91	0·22	1·1	0·015	2·8	0·81	0·904	2·16	39·8	4·5	54·8	0·9
9	0·25	1·56	1·81	2·21	0·76	3·0	0·057	5·1	2·06	0·862	2·15	38·3	6·1	54·2	1·4
10	0 42	2·34	2 76	3·27	1·47	4·7	0·124	5·1	3·18	0·848	2·51	38·0	6·8	53·2	2·0
11	0·94	4·70	5·64	6·68	4·69	11·4	0·127	5·7	6·58	0·833	3 51	37·8	7·5	53·7	1 0
12	1·25	5·90	7·15	8·45	5·68	14·1	0·217	5·3	8·40	0·825	3 17	37·3	7 9	53·4	1·4
13	1·99	9·48	11·47	13·19	9·56	22·7	0·267	6·3	13·46	0·826	3·45	38·0	8·0	52·9	1·1
14	0·27	1·61	1·88	2·26	0·57	2·8	0 025	5·1	2·14	0·856	1·51	38·6	6·5	54·3	0·6
15	1·16	4·49	5·65	6·86	3·98	10·8	0·108	5 1	6 81	0·794	2 25	35·6	9·2	54·4	0·8
16	1·00	3·71	4·71	6·15	5·58	11·7	0·116	5·8	5·71	0·787	3·37	33·8	9·1	56·0	1·1

* The ratio, if complete equilibrium at 1000° C. were attained in the CO, H_2O, CO_2, H_2 system, would be 1·6 according to Hahn.

per hour. By this extreme measure (experiment 24) a steam decomposition as low as 44·3 p.ct. was ultimately obtained, together with a water gas containing 10·6 p.ct. of carbon dioxide.

GASIFICATION OF LIME AND CALCIUM CARBONATE COKES.

(Series Nos. VI. and VII.)

The calcium oxide and carbonate cokes, the results of which are shown in Tables 4 and 4 (continued), gave steam decompositions intermediate between the figures obtained

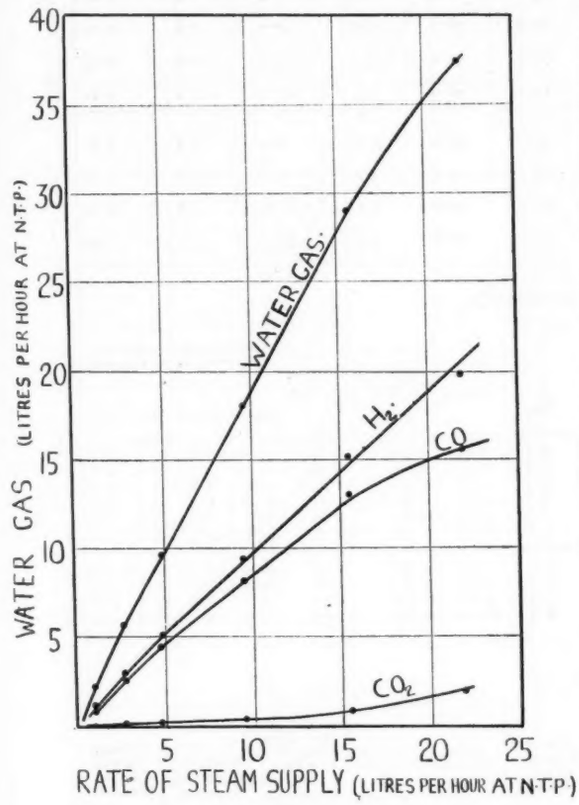


Fig. 3.—Water Gas from Iron Oxide Coke (10 gms.).

with "pure" and iron oxide cokes. No substantial difference was detected between the two cokes when gasified in steam. It should be noted, however, that no increase in the carbon dioxide content of the gas was indicated in the case of the calcium carbonate coke, as compared with the lime coke. In two experiments (Nos. 28 and 29) Hahn's equilibrium figures for the gaseous system CO, CO_2, H_2, H_2O were attained, but the high values obtained with the lowest steam velocities require further explanation. Steam decomposition fell from 87·8 to 77·5 p.ct., while carbon dioxide in the gas rose from 1·8 to 6·4 p.ct.

GASIFICATION OF SODIUM CARBONATE COKE.

(Series No. VIII.)

The most remarkable results obtained during the whole of this work were those of the sodium carbonate coke experiments—Tables 5 and 5 (continued), fig. 4. With steam velocities varying between 1 and 20 litres per hour, almost complete steam decomposition took place; the dry gas containing very nearly equal quantities of carbon monoxide and hydrogen, while the carbon dioxide never exceeded 0·7 p.ct. Too much reliance cannot be placed on the values obtained for the equilibrium constant, possibly on account of the small quantities of carbon dioxide and water vapour available for estimation.

The results of comparative experiments, described later, on this and the pure coke, using carbon dioxide instead of steam, indicate that the lowness of the carbon dioxide figure is explicable by the rapidity of its reduction to carbon monoxide.

GASIFICATION OF "ACTIVE" CARBON.

(Series No. IX.)

This carbon (containing 1 p.ct. of ash) was a commercial brand described as having been prepared from wood charcoal and as suitable for solvent recovery. It was graded in the same way as the cokes ($\frac{1}{6}$ to $\frac{1}{8}$ in. in size). Owing to its low apparent specific gravity, 5 grammes of carbon occupied the same volume in the reaction tube as 10 grammes of our "pure" coke, and was therefore used.

The results, which are given in Tables 6 and 6 (continued), are of the same order for the same time of contact as those in the calcium oxide and calcium carbonate series of experiments.

The property of "active" carbon of retaining liquids and gases is supposed to be due in part to the fact that the carbon contains a large number of capillary pores in which the liquid or gas is held by surface tension. Molecular attraction between adsorbed liquid and carbon is supposed to influence the amount of liquid retained; and it was thought possible that the carbon would exhibit marked properties when gasified in steam. However, no remarkable results were obtained. Gasification of this active carbon appeared to be chiefly a surface action in the sense that the size of the granules was much smaller after

TABLE No. 3.

Description.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming. Hrs. Mins.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified. Grammes per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.
Iron oxide coke (10 grammes)	V.	17	1·0	3 0	92·1	19·0	0·63	2·2	2 2	3·15
" " " "		18	2·7	1 25	94·7	24·2	1·7	5·7	2·1	1·6
" " " "		19	4·8	1 0	94·7	28·3	2·8	9·7	2·0	1·2
" " " "		20	9·6	0 45	91·4	38·9	5·2	18·1	1·9	0·74
" " " "		21	15·5	0 30	91·8	41·2	8·2	29·0	1·9	0·51
" " " "		22	21·9	0 20	84·2	35·1	10·5	37·4	1·7	0·39
Iron oxide coke (5 grammes).		23	18·8	0 20	65·6	43·7	6·6	24·3	1·3	0·24
Iron oxide coke (2·5 grammes)		24	15·5	0 20	44·3	43·2	3·2	13·0	0·8	0·15

TABLE No. 3 *(continued)*.

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents.								$\frac{CO}{2CO_2}$	$\frac{CO}{CO+CO_2}$	$\frac{(CO)\ (H_2O)}{(CO_2)\ (H_2)}$	Dry Gas Compositions. Percentages by Volume.			
	CO_2.	CO.	$CO + CO_2$.	H_2.	H_2O.	$H_2 + H_2O$.	CH_4.	N_2.				CO.	CO_2.	H_2.	CH_4.
17	0·034	0·97	1·00	1·15	0·08	1·2	0·015	3·0	1·04	0·970	2·01	44·7	1·6	53·0	0·7
18	0·088	2·63	2·72	2·99	0·14	3·1	0·042	5·0	2·81	0·967	1·40	45·8	1·5	52·0	0·7
19	0·16	4·50	4·66	5·06	0·25	5·3	0·079	5·1	4·82	0·966	1·39	45·9	1·6	51·7	0·8
20	0·47	8·19	8·66	9·40	0·82	10·2	0·118	5·4	9·13	0·945	1·52	45·0	2·6	51 7	0·7
21	0·79	13·00	13·79	15 17	1·27	16·4	0·157	5·7	14·58	0·942	1·38	44·7	2·7	52·1	0·5
22	1·87	15·70	17·57	19·82	3·47	23·3	0·211	5·7	19·44	0·893	1·47	41·7	5·0	52·7	0·6
23	1·83	9·40	11·23	13·04	6·48	19·5	0·150	6·3	13·06	0·837	2·55	38·5	7·5	53·4	0·6
24	1·39	4·32	5·71	7·29	8·62	15·9	0·140	5·5	7·10	0·756	3·68	32·9	10·6	55·5	1·0

TABLE No. 4.

Description.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming. Hrs. Mins.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified Grammes per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.
Calcium oxide coke (10 grammes)	VI.	25	1·1	2 45	87·8	18·6	0·68	2·3	2·1	2·9
Calcium oxide coke (10 grammes)		26	2·7	1 30	85·7	22 8	1·5	5·1	1·9	1·6
Calcium oxide coke (10 grammes)		27	4·9	1 0	83·8	26·0	2·6	8·8	1·8	1·2
Calcium oxide coke (10 grammes)		28	11·2	0 45	82·0	38·7	5·2	18·2	1·6	0·70
Calcium oxide coke (10 grammes)		29	21·6	0 25	77·5	39·0	9·4	33·9	1·6	0·41
Calcium oxide coke (5 grammes)		30	18·5	0 25	59·2	46·0	5·5	21·1	1·1	0·21
Calcium carbonate coke (10 grammes)	VII.	31	1·1	2 45	90·1	20·9	0·76	2·4	2·2	3·0
Calcium carbonate coke (10 grammes)		32	4·7	0 55	82·4	24·1	2·6	8·5	1·8	1·15
Calcium carbonate coke (10 grammes)		33	10·9	0 40	78·3	34·0	5·1	17·6	1·6	0·71
Calcium carbonate coke (10 grammes)		34	23·6	0 20	70·1	31·8	9·5	33·2	1·4	0·38

TABLE No. 4 (*continued*).

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents. CO_2.	CO.	CO + CO_2.	H_2.	H_2O.	H_2 + H_2O.	CH_4.	N_2.	$\frac{CO}{2CO_2}$.	$\frac{CO}{CO+CO_2}$.	$\frac{(CO)(H_2O)}{(CO_2)(H_2)}$.	Dry Gas Compositions. Percentages by Volume. CO.	CO_2.	H_2.	CH_4.
25	0·042	1·03	1·07	1·26	0·14	1·4	0·017	3·3	1·11	0·962	2·72	43·8	1·8	53·7	0·7
26	0·16	2·19	2·35	2·75	0·39	3·1	0·041	5·3	2·51	0·932	1·94	42·6	3·1	53·5	0·8
27	0·34	3·73	4·07	4·76	0·80	5·6	0·077	5·3	4·41	0·916	1·84	41·9	3·8	53·4	0·9
28	0·99	7·48	8·47	9·75	2·02	11·8	0·134	5·2	9·46	0·883	1·57	40·8	5·4	53·1	0·7
29	2·18	13·48	15·66	18·27	4·85	23·1	0·270	5·9	17·84	0·861	1·64	39·4	6·4	53·4	0·8
30	2·19	7·15	9·34	11·77	7·56	19·3	0·197	5·7	11·53	0·765	2·10	33·6	10·3	55·2	0·9
31	0·031	1·10	1·13	1·22	0·11	1·3	0·017	3·1	1·16	0·973	3·20	46·5	1·3	51 5	0·7
32	0·36	3·61	3·97	4·49	0·84	5·3	0·067	5·7	4·33	0·909	1·88	42·3	4·2	52·7	0·8
33	1·04	7·20	8·24	9·32	2·36	11·7	0·140	5·3	9·28	0·874	1·75	40·7	5·9	52·6	0·8
34	2·81	12·38	15·19	17·99	7·06	25·0	0·316	6·3	18·00	0·815	1·73	37·0	8·4	53·7	0·9

TABLE No. 5.

Description.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming. Hrs. Mins.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified. Grammes per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.
Sodium carbonate coke (10 grammes)	VIII.	35	1·0	3 0	99·2	25·0	0·83	2·2	2·2	3·3
Sodium carbonate coke (10 grammes)		36	4·8	1 0	100·0	32·8	3·3	10 2	2·1	1·1
Sodium carbonate coke (10 grammes)		37	9·9	0 30	98·5	34·1	6·8	20·5	2·1	0·69
Sodium carbonate coke (10 grammes)		38	16·1	0 20	98·2	35·9	10 8	33·4	2·1	0·47
Sodium carbonate coke (10 grammes)		39	21·4	0 15	99·3	35·9	14·4	44·7	2·1	0·37
Sodium carbonate coke (5 grammes)		40	20·2	0 15	85·3	56·3	11·2	37·7	1·9	0·20
Sodium carbonate coke (2·5 grammes)		41	19·3	0 15	69·3	73·6	7·4	26·6	1·8	0·11

TABLE No. 5 (*continued*).

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents. CO_2.	CO.	CO + CO_2.	H_2.	H_2O.	H_2 + H_2O.	CH_4.	N_2.	$\frac{CO}{2CO_2}$.	$\frac{CO}{CO+CO_2}$.	$\frac{(CO)(H_2O)}{(CO_2)(H_2)}$.	Dry Gas Compositions. Percentages by Volume. CO.	CO_2.	H_2.	CH_4.
35	0·0158	1·074	1·09	1·085	0·0075	1·09	0 017	2·9	1·11	0·985	0·47	49·0	0·7	49·5	0·8
36	0·039	5·03	5·07	5·11	*nil*	..	0·047	5·5	5·11	0·992	..	49·2	0·4	49·9	0·5
37	0·086	10·11	10·20	10·26	0·144	10·4	0·067	6·0	10·28	0·991	1·65	49 3	0·4	50·0	0·3
38	0·19	16·37	16·56	16·84	0·29	17·1	0·074	6·1	16·75	0·989	1·48	48·9	0·6	50·3	0·2
39	0·20	21·98	22·18	22·49	0·14	22 6	0·084	6·4	22·38	0·991	0·68	49·1	0·4	50·3	0·2
40	0·80	17·69	18·49	19·18	2·97	22·1	0·032	6·3	19·29	0·956	3·42	46·9	2·1	50·9	0·1
41	1·54	10 99	12 53	14·14	5·93	20·1	0·025	6·3	14·07	0·872	2·99	41·2	5·8	52·9	0·1

each experiment. This behaviour was quite different from that of the cokes, which became more porous without alteration in size over a considerable range of gasification.

LIBERATION OF SULPHUR AS HYDROGEN SULPHIDE FROM THE SPECIAL COKES DURING GASIFICATION IN STEAM.

No extensive examination was made of the sulphur liberated from the coke during its treatment with steam, but, in order to obtain an accurate value for the carbon dioxide produced, it was necessary to determine the hydrogen sulphide, which was simultaneously absorbed by the soda lime.

Typical results for the different cokes are collected in Table 7. It will be seen that the oxide of iron coke stands alone in that the percentage of the sulphur present liberated as hydrogen sulphide corresponds approximately with the percentage of coke gasified. In all other cases

a much smaller proportion of the sulphur passed into the gas as hydrogen sulphide, indicating a steady accumulation in the residue as gasification proceeded. The difference in behaviour in this respect of oxide of iron on the one hand, and lime and soda on the other, was very striking, and this was surprising with the lime because in that coke

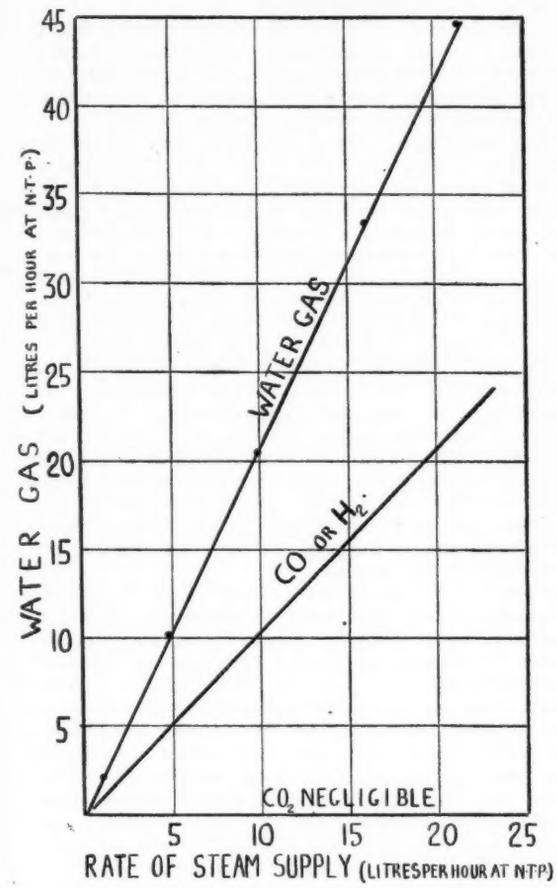


Fig. 4.—Water Gas from Sodium Carbonate Coke (10 gms.).

the " sulphide " sulphur was high. Some sulphur dioxide was evolved from the iron oxide coke, but its quantity was not estimated. No relation was observed between the rate of steam supply, or the percentage of steam decomposed, and the percentages of the sulphur in the coke obtained as hydrogen sulphide.

The examination of the gradual evolution of sulphur compounds from the cokes, as gasification proceeded, on the same lines as already reported for an ordinary coke by Pexton and Cobb (Gas Research Fellowship, 1923) remains to be carried out.

Liberation of Nitrogen.

This has not received examination, but it may be noted that in two series of experiments (calcium carbonate and sodium carbonate cokes) small deposits of ammonium chloride were found in the reaction tube.

Macroscopic and Microscopic Examination of the Special Cokes.

We are indebted to the Research Staff of the Gas Investigation Committee for the preparation, examination, and photographing of the coke specimens. [See figs. 52-55 of the Sixteenth Report, pp. 824-5 of this issue of the " JOURNAL."]

The method, which consists of filling-in the open cells and cracks of a ground and polished surface of coke with plaster of Paris, is fully described in the Sixteenth Report of the Gas Investigation Committee.

Comparing the photographs, it will be seen that the iron oxide and sodium carbonate cokes have a more homogeneous structure, with smaller pores, than the " pure " coke, and that the cell walls contain a large number of very small pores. The calcium oxide coke has apparently the same structure as that of the " pure " coke.

Comparison of the Steam Reactivities of the Special Cokes.

A method of obtaining comparative figures for the reactivity, with steam, of the different cokes at 1000° C. seems to be that of using the ratio

$$\frac{\text{Volume of dry water gas}}{\text{Volume of steam supplied}}.$$

This is constant over a considerable range of rates of steam supplied, as is indicated by the straight line por-

Table No. 6.

Description.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming. Hrs. Mins.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified. Grammes per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.
" Active " carbon (5 grammes)	IX.	42	2·4	1 ·0	86·2	35·2	3·5	3·9	1·6	1·7
" " "		43	4·9	0 45	82·8	44·9	6·0	8·0	1·6	1·1

Table No. 6 (*continued*).

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents.								$\frac{CO + 2CO_2}{}$	$\frac{CO}{CO+CO_2}$	$\frac{(CO)\ (H_2O)}{(CO_2)\ (H_2)}$	Dry Gas Compositions. Percentages by Volume.			
	CO_2.	CO.	$CO + CO_2$.	H_2.	H_2O.	$H_2 + H_2O$.	CH_4.	N_2.				CO.	CO_2.	H_2.	CH_4.
42	0·16	1·74	1·90	2·00	0·33	2·3	0·046	5·4	2·06	0·916	1·79	44·1	4·1	50·6	1·2
43	0·42	3·36	3·78	4·27	0·85	5·1	0·032	6·1	4·20	0·889	1·59	41·6	5·2	52·8	0·4

Table No. 7.

Liberation of Sulphur as Hydrogen Sulphide from the Special Cokes during Gasification in Steam.

Description.	Series No.	Experiment No.	Total Sulphur Content of Coke, P.Ct.	" Sulphide " Sulphur Content of Coke. P.Ct.	Coke Gasified P.Ct.	Sulphur in Coke Liberated as H_2S, P.Ct.	H_2S Found in Total Gasification Products. Grammes.
" Pure " coke	I.	4	0·67	0·010	31·0	7·6	0·0054
Silica coke	II.	11	0·63	0·005	28·2	12·2	0·0082
Alumina coke	III.	15	0·60	0·010	31·0	15·7	0·0100
Iron oxide coke	V.	20	1·06	0·16	38·9	38·5	0·0434
Calcium oxide coke	VI.	28	1·07	0·44	38·7	6·3	0·0072
Calcium carbonate coke	VII.	33	0·70	0·11	34·0	6·3	0·0047
Sodium carbonate coke	VIII.	37	0·80	0·11	34·1	5·5	0·0047

tions of the curves given in fig. 5, which are used for deducing these numerical values.

The water gas collected contains a small amount of gas derived from the original volatile matter of the cokes, and

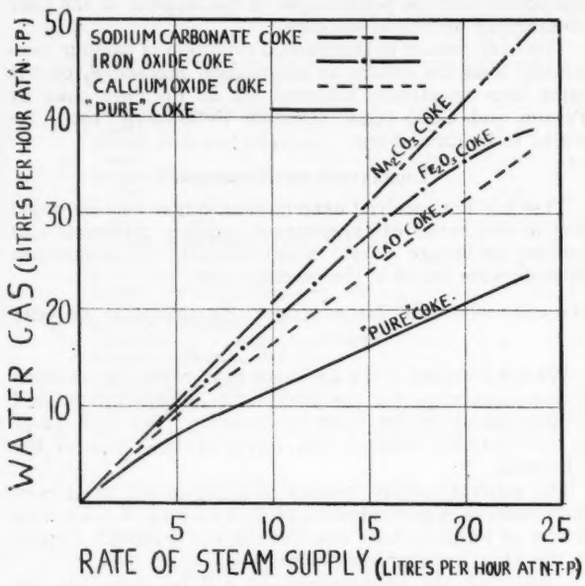


Fig. 5.—Water Gas from Special Cokes (10 gms.).

so is rather greater than the water gas made by direct decomposition of steam. The effect of this volatile matter is obvious with the sodium carbonate coke where the water gas found is slightly greater than the theoretical quantity, according to the equation $C + H_2O = CO + H_2$.

Adopting, therefore, this method, we have

$$\frac{\text{Vol. dry water gas}}{\text{Vol. steam supplied}}$$

Theoretical (100 p.ct. steam decomposition)	2·0
"Pure" coke	1·1
Calcium oxide coke	1·6
Iron oxide coke	1·9
Sodium carbonate coke	2·1

Another possible plan is to compare the percentages of steam decomposed at one rate of steam supply. Thus, with ten litres per hour would be obtained

	P.Ct. Steam Decomposed*
"Pure" coke	61
Calcium oxide coke	82
Iron oxide coke	91
Sodium carbonate coke	98

Experiments made with carbon dioxide instead of steam (see Table No. 9 below, and Table 11, Supplement) also indicate a striking method of displaying enhanced reactivity by comparison of the grammes gasified per hour, which, for example, is more than twenty times as great for the sodium carbonate as for the "pure" coke, and fifteen times as great for the "pure" coke impregnated with 2·5 p.ct. of sodium oxide.

Comparison with Previous Experiments and with Large-Scale Practice.

Attention has already been drawn to the gasification experiments reported in the Gas Research Fellowship Report of 1924, and some of the results obtained, together with those of large-scale practice, are collected for comparison with our results in Table 8.

It is significant that the low ash coke prepared at 800° C., and used by us as a standard, is less reactive than the higher ash coke prepared at 900° C., by Pexton and Cobb. Our standard coke more nearly resembles, in reactivity, their high-temperature coke, gasified at 1000° C.

It was noted that, after gasification, the residual coke appeared to occupy the same volume as before, and the individual pieces were apparently unaltered in size. This applies to all cokes examined by us, and confirms statements made in previous reports—*e.g.*, "the mode of combustion in steam normally appears to be an increase in porosity as gasification proceeds, with very little alteration in size until mechanical collapse of the weakening structure begins."* A different behaviour in the case of the "active" carbon examined has been already noted.

In the Gas Research Fellowship Report of 1924, it was pointed out that the hourly rate of gasification was dependent on the rate and independent of the partial pressure of the steam supply entering or leaving the mixture. Thus the use of increased quantities of nitrogen (as a carrier of steam) had no diluting effect on the reaction between the coke and steam. In confirmation of this, we carried out two experiments (with "pure" coke) using different rates of nitrogen and the same steam supply, and obtained similar results.

Our experiments show that the addition of various ash constituents to the coal before carbonizing results in marked differences when the prepared cokes are gasified in steam. Undoubtedly these differences are ultimately due to these additions, but the further question arises as to how far the increased steam reactivities observed are due to the presence in the coke, during gasification, of the added compound, and how far to modification of the physical form of the coke determined by the presence of the compound during its carbonization. Probably both factors enter into the result. Microscopic evidence is not conclusive, since the highly reactive calcium oxide coke differs little in appearance from the pure coke under the microscope, though the sodium carbonate and iron oxide cokes, even more reactive, do display a marked difference in structure from the pure coke, and that of a kind which might be expected to increase reactivity.

Experiments are now in progress whereby we hope to extract the added mineral matter from the highly reactive cokes, while preserving the coke structure. These treated cokes should furnish us with interesting results, when gasified in steam.

Parallel experiments are in hand in which the addition of the oxide or compound is made by impregnating the "pure" coke, so eliminating the effect on structure during carbonization and testing the more specific chemical effect of the addition.

* From the Gas Research Fellowship Report of 1924.

TABLE No. 8.

Description.	P.Ct. Ash.	Test or Experiment No	Composition of Dry Gas. CO.	CO_2.	H_2.	Vol. of Dry Water Gas Produced (Litres per Hour at N.T.P.) from 10 Grammes of Coke.	Rate of Steam Supply. Litres per Hour at N.T.P.	Vol. of Dry Water Gas. / Vol. of Steam Supplied	Average Time of Contact. Seconds.	Steam Decomposed. P.Ct.	$\frac{(CO)\,(H_2O)}{(CO_2)\,(H_2)}$.	$\frac{CO}{CO+CO_2}$
Gas Research Fellowship Report, 1924—900° C. coke gasified at 1000° C.	5·8	31	42·8	5·0	52·2	18·0	11·0	1·6	0·56	85·5	1·46	0·896
Do.—Bye-product coke gasified at 1000° C.	6*	19	31·3	12 5	56·2	11·2	10·2	1·1	0·48	62·0	1·54	0·714
This report—"Pure" coke	1·3	4	35·3	9·2	54·7	11·5	9·6	1·2	0·82	61·7	2·25	0·793
This report—Iron oxide coke	7·9	20	45·0	2·6	51·7	18·1	9·6	1·9	0·74	91·4	1·52	0·945
This report—Sodium carbonate coke	12·8	37	49·3	0·4	50·0	20·5	9·9	2·1	0·69	98·5	1·65	0·991
Tenth Report of the Gas Investigation Committee (Large Scale)	12·3	D	40·7	4·5	49·2	..	..	1·83	2–2½	71	4·0	0·900

* Approximately.

The question arises whether a coke which is known to be highly reactive with steam is also more reactive with carbon dioxide and air; and preliminary experiments to ascertain this, carried out for us by Mr. W. R. Branson, are in progress. As an example of results so obtained, the following figures for several of the cokes may be quoted (Table 9). A working temperature of 850° C. was chosen for these experiments.

TABLE No. 9.

Description.	Temperature.	Rate.	P.Ct. CO in Gas. $\frac{CO}{CO + CO_2} \times 100$	Time of Contact. Secs.	Grammes Gasified per Hour.
"Pure" coke	850° C.	6 litres per hour.	6·6	2·45	0·125
Iron oxide coke			29·9	2·3	0·58
Calcium oxide coke			45·6	2·1	1·04
Sodium carbonate coke			89·0	1·5	2·8

Other points interesting in practice, and which we wish to settle, are how far smaller additions than those already made will influence reactivity, and how far the effect is modified if the additions are made to coal of higher and more normal ash content. (See Supplement.)

WORK OF OTHERS.

It has been suggested that the reactions between coke and steam may be influenced by the presence of inorganic compounds in the ash. They may act either by increasing the rate of gasification of the carbon ($C + H_2O = CO + H_2$, and $C + 2H_2O = CO_2 + 2H_2$), or by hastening the attainment of the water gas equilibrium ($CO + H_2O \rightleftarrows CO_2 + H_2$. The possible influence of iron oxide upon the latter reaction has frequently been quoted as an example.

Records of experimental work, aimed at testing these theories, are very few in number. It is known, however, that iron oxide is an important constituent of the catalyst used in the manufacture of hydrogen from water gas. A number of patents have been taken out for adding various compounds to the carbon before gasification. For example, Dieffenbach and Moldenhauer (1) proposed to use potassium carbonate and lime, the object being to obtain a charcoal or coke having a lower temperature of decomposition when steamed, and giving hydrogen free from carbon dioxide. Reference was made in Part I. of this paper (Gas Research Fellowship, 1925) to patents which claimed increased advantages in carbonization and gasification as a result of adding lime or iron oxide to the raw coal.

The Gas Research Fellowship Report of 1924 (2) described experiments carried out on the gasification of low, medium, and high temperature cokes at the two temperatures of 900° C. and 1000° C., and in no case was a good water gas, low in carbon dioxide, obtained at a gasification temperature of 900° C. At 1000° C. the quality of the gas varied according to conditions; but, where large quantities of steam escaped decomposition, the water gas contained large quantities of carbon dioxide, sometimes with, and at higher speeds without, attainment of equilibrium in the gaseous products. Furthermore, the rate of gasification of the coke examined depended on its temperature and the method of its preparation, while it was pointed out that the high iron content of the coke ash might be partly responsible for the rapid attainment of the water gas equilibrium observed in some cases.

Gwosdz (3) carried out some experiments in which steam was passed over different types of carbon at temperatures varying between 560° C. and 855° C.; the gasification products being collected and analyzed. Using gas coke and wood charcoal, considerable quantities of carbon dioxide were always found, but an ash-free carbon gave much smaller quantities of this gas. Gwosdz, considering the four reactions

(1) $C + H_2O = CO + H_2$
(2) $C + 2H_2O = CO_2 + 2H_2$
(3) $C + CO_2 \rightleftarrows 2CO$
(4) $CO + H_2O \rightleftarrows CO + H_2$.

is of the opinion that (1) is the primary and (4) a secondary reaction; the carbon monoxide formed in (1) reacting with excess steam according to (4), the latter reaction being influenced by the ash in the carbon.

Taylor and Neville (4) investigated the effects of catalysts on the reaction of carbon with steam at temperatures of 490°, 525°, and 570° C. Various types of carbon, to which the catalyst had been added previously, were gasified in a current of steam. They found that many substances accelerated the reaction between carbon

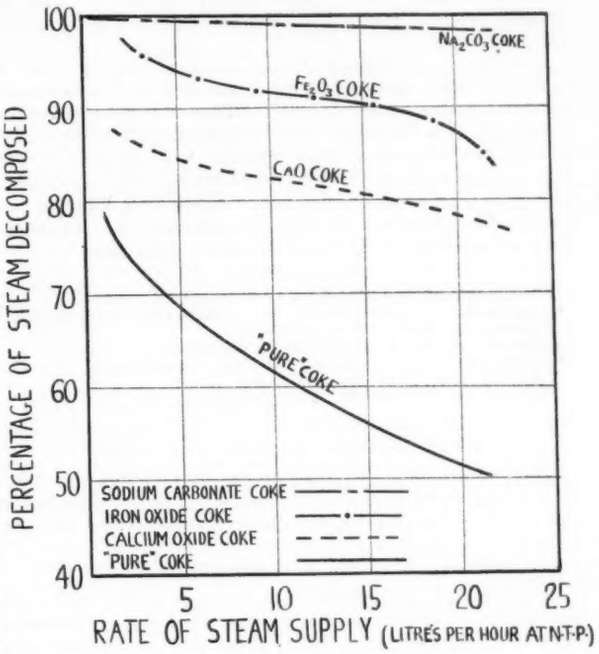


Fig 6.—Percentages of Steam Decomposed.

and steam, but the most pronounced effects were observed with sodium and potassium carbonates. They showed that iron oxide, which is believed to catalyse the water gas reaction, did not hasten the initial interaction between steam and the carbon. They concluded that the acceleration of the reaction between carbon and steam by alkali carbonates is due to catalysis of the reaction $C + CO_2 = 2CO$. This carbon monoxide is at liberty to react with excess steam forming additional quantities of carbon dioxide and

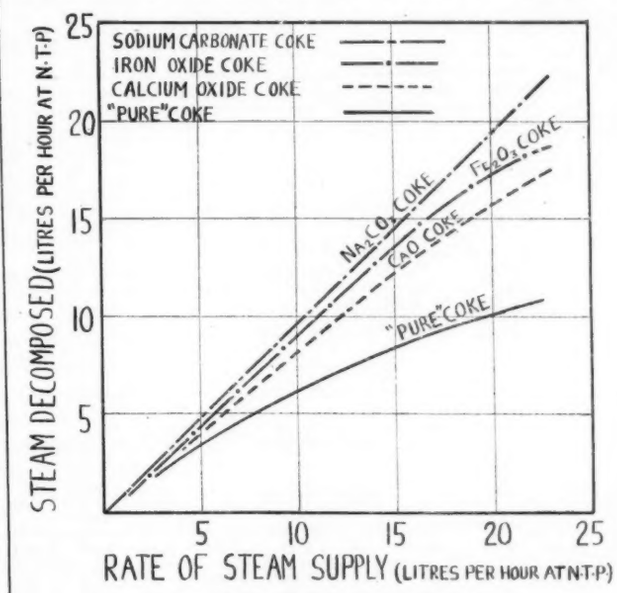


Fig. 7.—Volumes of Steam Decomposed.

hydrogen, thus increasing the net yield of gas from the steam-carbon reaction, and consequently the percentage of steam decomposed and the rate of gasification. Taylor and Neville confirmed this theory by passing carbon dioxide over the special carbons at various temperatures. They found that the quantities of carbon monoxide pro-

duced from carbons containing sodium and potassium carbonates were much greater than those from the untreated carbon or the carbon treated with iron oxide. As an explanation of this catalytic effect, the theory is put forward that increased adsorption of carbon dioxide (found by experiment) is due to the action of the catalytic agents in facilitating the decomposition of fixed oxygen complexes (CxOy) on the carbon surface, thus cleaning the surface to an extent which would ordinarily only be attained by subjecting the carbon to considerably higher temperatures.

According to Vignon [5] the mineral matter, and in particular lime, present in coke, resulted in the formation of considerable quantities of methane during gasification in steam, but Tropsch and Schellenburg [6] were unable to confirm Vignon's experiments, and suggested that Vignon had confused methane with nitrogen in his analyses. Our own experiments with cokes containing lime, or any other added ash constituent, did not show any increased amount of methane in the gasification products.

REFERENCES.

1. Dieffenbach and Moldenhauer, English Patent 8734, 1910.
2. Gas Research Fellowship Report, 1924. Transactions of the Institution of Gas Engineers, 1923-24, pp. 292-325.
3. Gwosdz. Z. Angew. Chem. 1918, **31**, pp. 137-140.
4. Taylor and Neville. J. Amer. Chem. Soc., 1921, **43**, 2055.
5. Vignon. Ann. Chem., 1921, **15**, 42-60.
6. Tropsch and Schellenburg. Brennstoff-Chem., 1922, **3**, pp. 33-37.

SUPPLEMENT (dated Aug. 9, 1926).

The postponement of the Annual Meeting of the Institution has enabled us to carry out further experiments, the results of which are shown in Tables 10 and 10 (continued).

PREPARATION AND DESCRIPTION OF COKES.

Mixtures of coal, containing 1, 2, 3, and 4 p.ct., respectively, of iron oxide, were carbonized at a temperature of 800° C. in the usual way. The 1 p.ct. iron oxide coke was porous, spongy, and similar in appearance to the "pure" coke, but the 2 p.ct. coke showed a decrease in the number of large pores, being hard and compact, these characteristics becoming more marked with the 3 and 4 p.ct. additions.

Another mixture of coal was prepared, with 5 p.ct. of added ash, the latter being obtained from the same Sharlston Wallsend coal and of the following composition :—

	P.Ct.
Silica (SiO_2)	41·4
Iron Oxide (Fe_2O_3)	11 3
Aluminium oxide (Al_2O_3)	29·0
Calcium oxide (CaO)	5·5
Magnesium oxide (MgO)	1·8
Sulphuric anhydride (SO_3)	4·4
Not estimated	6 6
	100 0

The quantity of ash was thereby increased without altering its composition.

The resulting coke was slightly more homogeneous and compact, and contained fewer large pores than the "pure" coke.

A coal mixture containing 0·5 p.ct. of sodium oxide added as carbonate was also carbonized. Its appearance differed little from that of the "pure" coke.

Lastly, a quantity of sieved and graded "pure" coke was boiled in a 10 p.ct. solution of sodium carbonate and dried. By this means a coke was obtained which possessed the physical characteristics of the untreated coke, while at the same time it contained approximately 2½ p.ct. of Na_2O as carbonate.

GASIFICATION OF THE PREPARED COKES IN STEAM AT A TEMPERATURE OF 1000° C.

One experiment only was carried out with each coke, the rate of steam supply being approximately 10 litres per hour in each case. The results obtained are shown in Table 10, together with several others which have been previously recorded, the latter being included to facilitate comparison.

IRON OXIDE COKES.

(*Series No.* X.)

Comparing these results with those obtained from "pure" coke, it will be seen that the addition of even 1 p.ct. of iron oxide to the coal before carbonization exerts a remarkable effect on the degree of steam decomposition, and the composition of the water gas generated. This is all the more interesting when it is remembered that this coke differed little in appearance from the "pure" coke, which would indicate that the increased reactivity was due to a specific catalytic chemical effect

TABLE No. 10.

Description.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming. Hrs. Mins.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified. Grammes per Hour.	Vol. of Dry Water Gas Produced Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.
"Pure" coke	1	5X	10·2	0 55	63 2	31·3	3·4	12·4	1·2	0·79
1 p.ct. iron oxide coke	X.	44	9·1	0 45	86·3	36·8	4·9	16·45	1·8	0·79
2 " " " "	"	45	11·1	0 40	84·8	39·9	6·0	19·8	1·8	0·67
3 " " " "	"	46	10·7	0 40	88·0	39·0	5·8	19·4	1·8	0·71
4 " " " "	"	47	9·4	0 40	91·1	34·1	5·1	17·7	1·9	0·78
5 " " " "	V.	20	9·6	0 45	91·4	38·9	5·2	18·1	1·9	0·74
Coke with increased ash.	XI.	48	10·6	0 15	78·3	34·1	4·5	16·6	1·6	0·72
0·5 p.ct. sodium oxide coke	XII.	49	10·6	0 40	79·5	29·5	4·4	15·9	1·5	0·77
Impregnated coke containing 2·5 p.ct. sodium oxide	XIII.	50	9·1	0 40	92·1	37·8	5·7	17·1	1·9	0·78

TABLE No. 10 (*continued*).

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents.								CO + 2CO₂.	CO / (CO+CO₂)	(CO)(H₂O) / (CO₂)(H₂)	Dry Gas Compositions. Percentages by Volume.			
	CO_2.	CO.	CO + CO_2.	H_2.	H_2O.	H_2 + H_2O.	CH_4.	N_2.				CO.	CO_2.	H_2.	CH_4.
5X	1·21	4·32	5·53	6·88	3·74	10·6	0·113	5·2	6·74	0·781	1·94	34·5	9·7	54·9	0·9
44	0·62	7·25	7·87	8 58	1·24	9·8	0·093	5·1	8·49	0·922	1·69	43·8	3·7	51·9	0·6
45	0·70	8·80	9·50	10·30	1·68	12·0	0·114	5·5	10·2	0·926	2·05	44·2	3·5	51·7	0·6
46	0·64	8·75	9·39	10·03	1·28	11·3	0·135	5·0	10·0	0·932	1·74	44·7	3·3	51 3	0·7
47	0·48	8·12	8·60	9·11	0·84	9 95	0·058	4·9	9·08	0·944	1·56	45·7	2·7	51·3	0·3
20	0·47	8·19	8·66	9·40	0·80	10·2	0·118	5·4	9·13	0·945	1·52	45·0	2·6	51·7	0·7
48	0·99	6 63	7·62	8·96	2·30	11·26	0·160	5·7	8·61	0·870	1·72	39·6	5 9	53·5	1·0
49	1·15	6·16	7·31	8·58	2 17	10·75	0·097	4·8	8·46	0·843	1·35	38·5	7 2	53·7	0·6
50	0·40	7·85	8·25	8·83	0·74	9·6	0·010	5·2	8·65	0·951	1·64	45·7	2·3	51·4	0·6

rather than to alteration in the physical structure of the coke.

COKE WITH INCREASED ASH.
(*Series No.* XI.)

The experiments just described demonstrated that small quantities of iron oxide exercise a pronounced effect. It follows that intimate admixture of a coal with an ash containing iron oxide in a free or potentially reactive condition might be expected to produce a more highly reactive coke. This result was obtained in experiment 48, where the steam decomposition (compared with the "pure" coke) increased from 61·7 to 78·3 p.ct., and the carbon dioxide in the water gas decreased from 9·2 to 5·9 p.ct.

0·5 P.CT. SODIUM OXIDE (AS Na_2CO_3) COKE.
(*Series No.* XII.)

This coke was almost identical in appearance with the "pure" coke, yet the steam decomposition was appreciably increased by the addition of the small quantity of soda, prior to carbonization.

IMPREGNATED COKE, CONTAINING APPROX. 2·5 P.CT. SODIUM OXIDE (AS Na_2CO_3).
(*Series No.* XIII.)

This experiment in which the steam decomposition was increased from 61·7 to 92·1 p.ct., simply by previously impregnating the "pure" coke by boiling in a dilute solution of sodium carbonate, plainly shows that the increased reactivity of the sodium carbonate coke is due to the catalytic effect of the sodium carbonate during the gasification in steam, rather than to the change in physical structure of the coke induced during the preceding carbonization.

This impregnated coke was also gasified in a current of carbon dioxide (by Mr. W. R. Branson), and its behaviour was again indicative of increased reactivity as shown in Table 11. The carbon monoxide was more than ten times as high in the exit gas for the impregnated coke, as compared with the "pure" coke, and the grammes gasified per hour fifteen times as great.

TABLE 11.—*Temperature* 850° *C. Rate of* CO_2 *Supply* 6 *Litres per Hour.*

Description.	P.Ct. CO in Exit Gas.	Time of Contact.	Grammes Gasified per Hour.
"Pure" coke	6·6	2·45	0·125
5 p.ct. Na_2O coke	89·0	1 5	2·8
"Pure" coke impregnated with 2·5 p.ct. Na_2O	69·8	2·1	1·85

Prof. COBB, introducing the report, said: I shall not at this late hour detain you with any long account of the work which forms the subject of the Gas Research Fellowship Report for this year; but in justice to my collaborator I should like to say something about it by way of introduction, because it probably constitutes, I think, one of the most important papers that has come forward in connection with that Fellowship. If the gas industry is to make its mark in competition with up-to-date scientific methods, such as are applied by its great rival, the electrical industry, then a proper appreciation of such subject-matter as comes into this paper is, in my opinion—and, I think, in the opinion of most of those who have given careful consideration to the subject—absolutely necessary.

In following up the systematic study of the behaviour of coke gasified in steam and other atmospheres, Dr. Marson and I last year presented a report of the Gas Research Fellowship dealing with the influence of the ash constituents. We prepared a number of cokes by the addition of such substances as silica, oxide of iron, and sodium carbonate, in turn, to a coal of the lowest possible ash content, about 1 p.ct.—the amount of oxides added being 5 p.ct., so as to obtain one constituent in a dominating proportion. A description of these cokes was made last year, and fully confirmed statements which had previously been made in this connection by Dr. Lessing. This year we have gone on to determine their behaviour on gasifying in steam. The results obtained are in some respects very remarkable.

It has been very clearly demonstrated that the addition of such substances as oxide of iron, and particularly of sodium carbonate, increases in a very marked way the reactivity of the coke towards steam. In the first place, the percentage of the steam decomposed is much greater for the special cokes. Thus with a steam supply of 10 litres per hour to 10 grammes of coke, the percentages of steam decomposition were 61 for "pure" coke, and 82, 91, and 98 for the calcium oxide, iron oxide, and sodium carbonate cokes respectively; while the corresponding percentages of CO_2 in the water gas made were 9·2, 5·4, 2·6, and 0·4 respectively. The results obtained with steam were so remarkable that it was thought desirable at once to obtain some parallel figures when CO_2 is used instead of steam. Mr. W. R. Branson did that for us; and the same differences betwen the cokes were forthcoming in an enhanced degree. The percentages of CO, found after passing CO_2 at the same rate through different cokes, were 6·6, 29·9, 45·6, and 89·0 for the "pure" coke, iron oxide coke, calcium oxide coke, and sodium carbonate coke respectively; while the enhanced reactivity is also strikingly displayed by the figure for grammes gasified per hour, which is more than twenty times as great for the sodium carbonate coke as for the "pure" coke.

It is advisable to settle, as soon as possible, one or two important points in this connection; and experiments are on the way, aimed at answering the questions as to how far smaller additions than those already made will influence reactivity, and how far the effect is modified if the additions are made to coal of a higher and more normal ash content.

Results already obtained are reported in the Supplement. They indicate that smaller additions were effective, even in some cases when the physical structure of the coke had not apparently been appreciably modified. It was established that a coke in which the ash content had been raised by the addition of more of the same ash was rendered more reactive thereby.

It must be pointed out, as likely to be of primary importance, that intimate contact of the ash constituent with the coal—that is, thorough distribution of the ash through the coal—had been secured in all these experiments by grinding and mixing before carbonization.

One interesting point that arises is how far the increased reactivity of the coke is due to an alteration in the physical structure brought about by the differences in behaviour during carbonization, and how far it is due to a specific chemical influence arising from the presence of the added oxides in the coke. No doubt both must play some part. We have, however, made some experiments by adding sodium carbonate to the coke itself, made from the pure coal without addition; and both in steam and CO_2 it would appear that the enhanced reactivity can be obtained in this way—that is, that the increased reactivity is in the main due to the presence of the added substance in the coke itself, and not to the alteration in physical structure on carbonization, which resulted from the addition.

These observations are interesting theoretically, and may have numerous industrial applications in connection with such processes as water gas manufacture, the generation of hydrogen, blast furnace work, and the combustion of solid fuels in air or oxygen.

Discussion.

The PRESIDENT: Is it your wish, at this late hour, that we should adjourn further consideration of this report until the morning? Prof. Cobb, as you have heard, attaches the greatest importance to it, and Dr. Marson, his collaborator, can be here in the morning to introduce the report and give a summary of it. I think it would be interesting to have one or two remarks from the Research Chemists on this particular subject. I may say at once that I attach such importance to the results myself that I have spoken to my Assistant about them, and we are going at once to start some practical experiments following on the lines of development in this report. That is the impression it has had on me; so that if you see no objection, I propose to take Mr. Marson first thing in the morning.

Mr. W. J. SMITH (Bolton): I think the report is of such importance that we ought to take it in the morning.

The PRESIDENT: Then we will do that unless anybody has a special question to put now.

Mr. W. J. SMITH (Bolton): With regard to the admixture of sodium salts to the coke structure, I take it that at the temperature of many vessels when water gas is being produced, there would be danger for the firebrick lining of the vessel.

Prof. COBB: That is one of the practical considerations which would have to come into play.

Mr. SMITH: I take it that in many cases the temperature of the water gas reaction would be sufficient to cause damage.

Prof. COBB: With an excessive amount of sodium carbonate I think that would be so. How much sodium carbonate is necessary is a thing we are still going into, and it has been partly examined.

Dr. R. LESSING: I have an important appointment in the morning, and cannot be present, but I would not like this report to go without expressing my high regard for the work that has been done. As Prof. Cobb pointed out last year, when the first part of the research was given, I was one of those who started years ago directing attention to the importance of the inorganic compounds on the process of carbonization—and, in fact, not only upon carbonization, but also on the combustion of coal. The work now being carried out at the Leeds University is of the utmost importance, in my opinion, and is now being recognized as such by many engineers, and certainly by many chemists. I think the work must be encouraged, and carried out on a very much larger scale; and I hope that questions such as those which arise out of it, and which are naturally being asked by the engineer, as to the influence (say) of

sodium carbonate or other additions made to coal upon our refractory materials, will not be allowed to stand in the way, in the initial stages, of the fundamental researches which have to teach us, in the first instance, what happens. If we find—as I have not the slightest doubt we shall find—that the preparation of coal for the carbonizing process is a subject of enormous development, then it is merely a question of engineers on the other side providing materials which will stand the side reactions which are possibly occasioned, and which are bound to be different from those which obtain to-day in the gas retort. I hope you will pardon me for intervening, because I shall not have an opportunity of saying this to-morrow; but I do think that every effort should be taken to encourage the work which is so excellently carried on by Prof. Cobb and his staff.

The PRESIDENT: Prof. Cobb has indicated that this work is going to be carried further. I can assure Dr. Lessing that if the chemists show us the way, he need not fear but that the engineers will follow.

The meeting then adjourned.

On the resumption of the proceedings on Thursday, Dr. C. B. MARSON outlined briefly the Report of the Institution Gas Research Fellowship, following the introduction by Prof. Cobb on Wednesday.

The PRESIDENT: I am hopeful that this most important investigation will be kept in mind by you all, and I hope that there are those present who can contribute to the discussion. Though, of course, this is an interim report to a great extent, I am sure you will all agree that it creates thoughts of lines of investigation in a practical manner which we shall do well to follow up. We cannot all follow these things, because time does not permit; but if one or other of us takes one particular line, and follows it, it will be very helpful to the industry as a whole. As I said yesterday, and will repeat now—do not think I am merely preaching to you, because I am trying to do it myself—I am going to experiment on the iron oxide mixture in connection with carburetted water gas manufacture. Of course, it is obviously convenient to apply it to the structure—as it is put by the authors—rather than to have to impregnate the body of the coke, which, as we all know, is a difficult physical operation, as well as being expensive.

Dr. A. PARKER (Fuel Department, University of Leeds): I think I would rather some other member of the Institution had opened the discussion, because, of course, working at the University as we are now, I have been more or less following through Dr. Marson's work; and we in the Research Committee consider the results so interesting and valuable that we are examining on certain lines—not quite so deeply from the chemical point of view—the cokes prepared in the "cronite" retort, to which reference was made in the Sixteenth Report of the Gas Investigation Committee. We are examining those cokes by methods similar to those described in this Gas Research Fellowship Report. To my mind, the most important thing that has come out so far is that, though this particular coal carbonized with sodium carbonate produces a coke which is much more reactive towards steam and carbon dioxide than the coke prepared in exactly the same manner from the coal itself, and though that more reactive coke with sodium carbonate has a very different structure, and we might at first attribute the greater reactivity to the change in structure, yet one can start with coke prepared by carbonizing the coal itself, saturate the coke with sodium carbonate, dry it, and in that way increase its reactivity without altering its structure. This brings us right away from prevalent ideas on coke reactivity and structure. It has frequently been stated in recent papers on coke, especially in connection with those used for domestic purposes, that coke with small pores and thin cell walls is much more reactive than coke with large pores and thick cell walls. One would expect that to be the case; but in the light of these experiments one wonders whether that really is so, because it is possible to produce from the same coal two cokes of entirely different structure, and yet of the same reactivity. Apparently the alteration in reactivity is due to the addition of this other chemical compound, sodium carbonate, or iron oxide, or, in another case, lime, so that it makes the subject at the moment one of extreme interest. Purely visual examination of coke for structure apparently will not give us a true idea of its reactivity; it must be properly tested. The cokes prepared by carbonizing coal with sodium carbonate are more dense in appearance, and they are certainly much harder. They should withstand transport more readily than coke from the coal itself. Of course, we realize that, before work of this kind can be translated into a practical proposition, very much more has to be done. As mentioned yesterday afternoon, there may be some action of the added materials on refractories; and a number of other points must be taken into account. I should like to mention another point, and that is the determination of reactivity. Several methods of determining reactivity have been brought out—*i.e.*, of determining the speed with which coke reacts with steam, carbon dioxide, and air. In the case of Dr. Marson's work, these experiments are really and truly comparative; but the difficulty in determining the reactivity of an ordinary coke is in obtaining an average sample. If one takes a bulk of coke and grades it, then the different grades of sizes will contain different percentages of ash; and unless special methods are taken for obtaining the particular grading for the particular reactivity experiment, the ash content of the sample may be very different from the average ash content of the original bulk of coke. These experiments show what an influence the ash content of the original coke has. The great difficulty in experiments on the reactivity, combustibility, and ignitibility of coke as ordinarily manufactured is in preparing a really true average sample; otherwise the results will not be of value. One rather amusing point comes out from the report. We find that washing soda added to coke increases its reactivity; and one wonders whether there might be something in some of these compounds which have been sold in packets of a few ounces to make one ton of coal go as far as two tons. The only point in these mixtures is this. They are usually sold in packets of a few ounces; but to get an appreciable difference it would appear, from Dr. Marson's results, that at least 1 p.ct. of the weight of the coal or coke must be used. Well, 1 p.ct. of a ton is 22 lbs., so that I do not think the compounds which have been sold up to the present are of any real value. But on making inquiries we do find that there have been recipes given in old books. Dr. Marson has handed me a statement which he found in some old cookery book, where it advises the addition of washing soda to coke in order to make it burn up more readily. I think Dr. Marson knows where this has come from, as well as the age of the book; and I will leave him to deal with it in his reply to the discussion.

Mr. H. E. COPP (Member of Council, of Hull): I should like to ask Dr. Marson if he can give us some idea of the intimacy of the mixture of coke with these various oxides, because I think that has an important bearing on this question. If the mixing is going to be difficult, and you have to come down to anything like colloidal mixtures, I am afraid the whole thing does not show much promise of practicability. Of course, another important matter is whether Dr. Marson considers that, having obtained an increased degree of reactivity by these various mixtures of oxide, the increased reactivity in steam is any indication of the coke being more likely to burn freely in air. That is an important point, I think.

Mr. H. D. MADDEN (Vice-President, of Cardiff): This is a subject in which I have been very interested; more particularly about fifteen years ago, when the Company with which I am connected were sinking a well for fresh water. Unfortunately, as the works are fairly near the sea, instead of getting fresh water, we got brackish water from the marl, with a high percentage of sodium chloride and other salts. My Directors at that time felt that this water might be injurious for coke quenching and cooling purposes—it was intended for those purposes, I think, and not for boiler work—and we conducted some experiments on coke in order to see the effect. We found, to our great surprise, that the value of the coke, from an ignition point of view and a burning point of view, was very much better when quenched with the brackish water from this well than when quenched with the ordinary town water. It does seem, therefore, that there is something to be said on this matter, and on the field for investigation which the report has opened out—especially in these days, when coke is becoming so much more valuable a fuel.

Mr. J. P. LEATHER: I was going to ask a question which has already been asked, as to whether these experiments do point to a greater reactivity of the coke in ordinary combustion with oxygen. They deal entirely with the effect with steam and carbon dioxide. The point that struck me was that we have no suggestions as to the theory of how these catalysts work; but the oxides which have been tried show that those which are acid—silica for instance—have practically no effect. It is those which can combine with carbon dioxide which have the effect. I am wondering whether there is something more of a combination of carbon dioxide with the oxide, and then, of course, decomposition again, and then again combination between the carbon dioxide and the lime. In the case of sodium carbonate, of course, the sodium carbonate is supposed to be to some extent decomposed by heat, and there would be a question of combination and decomposition—I do not know how to put it, because I did not expect to have this discussion, but I had the report early last night and read it through; and it seems very interesting from the purely scientific point of view. I want to know whether Dr. Marson or any of those who have been associated with him have formed any theory as to how these catalysts act. Such an idea as I have just put forward, of combination and decomposition, might open out the question of the freeing of electrons—about which we hear so much in connection with chemical phenomena nowadays—which would permit this action. I do not know, however, if this would explain it if these oxides or sodium carbonate also affect the combustion of coke. Therefore, I should like to know whether anything has been done to find out whether the coke has a greater reactivity in ordinary combustion with air.

Mr. W. C. JONES (Brierley Hill, Staffs.): Last year there was a discussion in the Midlands on coke, and I remember one speaker saying that by accident his ammoniacal liquor well overflowed, and ran on to the coke. Very shortly afterwards one of his customers came to his works and spoke to him about his coke. He thought his customer was going to complain bitterly about it, because it was saturated with ammoniacal liquor. The customer remarked, however: "I want some

more like it, because I have never had any to burn like it before." I should like to know whether any experiments have been made in this direction.

Mr. T. F. E. RHEAD (Birmingham): I congratulate the authors upon presenting us with beginnings which may lead to some fundamental and valuable work on coke structure, coke reactivity, and so forth. I think, however, that a word of warning to those who are too enthusiastic in experimenting might be useful—namely, that you must look after your refractories. Anyone who has to experiment had better do so in retorts which he thinks will need repair soon, because iron oxide or a small percentage of sodium oxide will "do in" the retorts very quickly. I do not suggest this to damp the enthusiasm of experimenters; but I want to utter a warning not to start experiments in new plant. I should like to ask whether the authors have followed what I call the history of the swelling of the coal. I am in the middle of a considerable amount of work on swelling—not simply the final effect that you get when you heat a coke to 800° or 900° C., but the progress of the swelling from incipient fusion at 200° or 300° C. up to 550° C., when, of course, it starts to contract, and probably contracts considerably at 800° C. I wonder whether the addition of these various chemicals, particularly the sodium carbonate, affects the swelling (say) at 450° or 500° C., and whether there is considerable contraction afterwards, or whether the coal does not swell at all during the fusion, gasification, and final coking.

The PRESIDENT: I am afraid we have no more time for discussion, but useful inquiries have been made, with which Dr. Marson will deal. Of course, this investigation, you will understand, is being continued on lines that suggest themselves from the present results. There is only just one point which occurs to me, and which possibly may have some reference to the matter. Many of you will remember, a good many years ago—I do not think it is practised at all now—in connection with sulphur purification, what I think was called the Cooper's liming process, and I cannot help thinking that if we had had in those days investigations such as those of Dr. Marson we might have found out a good many things theoretically, in addition to the practical result of adding the lime to the coal, with a view to assisting in the sulphur purification. It just shows how important it is for us to-day to proceed guided by the research chemist.

Dr. MARSON, replying to the discussion, said: I am very pleased that Dr. Parker has brought out the point that it is not necessarily the fine structure of the coke which influences its reactivity. Mr. Copp has asked how fine a mixture we suggest. The whole series of experiments is still in its early stages. At present we have confined our experiments to a coal which has been ground and passed through a 20-mesh sieve; and I would point out that the question of what size of coal we need to obtain these results is still under consideration, and will probably be dealt with during the next year. Mr. Copp also asks how far the increased degree of reactivity is influenced when the cokes are burned in air. The natural course of procedure in this work was, first of all, to examine their behaviour in steam, then in carbon dioxide—that is already being done at Leeds at present—and finally in air. I might mention that we have had some preliminary experiments carried out with the sodium carbonate coke. The ordinary untreated coke was boiled, in a large vessel, in a 10 p.ct. solution of sodium carbonate, and dried, and then burned in an open fire; and I do not think any of us at Leeds have ever seen a coke fire like it before. It was far too hot, with carbon monoxide flames roaring up the chimney. This points out in any case that the sodium carbonate coke does burn much better in air. I was very interested to hear Mr. Madden's comments on the salty water which he used for quenching. This is also a matter on which we are going to carry out some work during the coming year, when we are going to quench some ordinary coke in sodium carbonate. I have no doubt we shall find that the coke will be much more reactive. Mr. Leather also mentioned the question of experiments with air. I have already answered that question in reply to Mr. Copp. With regard to the theory as to how these properties are produced, I have to tell Mr. Leather that we did not touch on it because we do not know much about it. (Laughter.) We shall be very thankful for any theories that will help us. We have not followed through the history of the swelling of the coke.

The PRESIDENT: I am sure we are all much obliged to Dr. Marson, and wish him success in his further experiments. In case my enthusiasm for this particular subject may have led us a little too far forward, let me impress upon you that these results are purely experimental. Anybody who takes up the work on anything like a practical scale at the present point must necessarily incur considerable risk in what he does. At least, there is no recommendation of any sort in this paper by Dr. Marson; it is simply a record of what has been done. Any enthusiastic work which follows this must be done on our individual responsibility. We must not blame the research chemist if we pursue a line which, on further investigation, might not be found to be thoroughly practical. I want this to be clearly understood, because there are certain bodies which influence the refractories, and other things to be considered. We must be prepared individually to take the risk.

THOMAS VALE & SONS

STOURPORT, Worcs. LTD.

Telephones: 62 & 63 Stourport. *Telegrams: "Vale Stourport."*

COMPLETE INSTALLATIONS OF

HORIZONTAL RETORTS

(Klönne Regenerative System).

GASHOLDER TANKS

Brick & Puddle, Mass Concrete, Reinforced Concrete.

RAILWAY SIDINGS

PILE DRIVING. FOUNDATION WORK.
BREAKER PITS. - - HOPPERS.

Retort House and Reinforced Concrete Buildings.

DISTRIBUTION OF GAS AT HIGH PRESSURE.

By ARTHUR W. SUMNER, A.M.I.Mech.E., of Grays, Essex.

The attention of the gas industry has been directed to the Government's electricity development scheme, which, as is well-known, is a scheme to provide super-stations for generating electricity and to distribute it throughout the country by a network of cables. It is generally agreed that the gas industry takes no exception to the scheme, providing the Government does not place the electrical industry in a more advantageous position than the gas industry. Assuming, therefore, the gas industry desired to carry out a similar scheme, is it able, willing, and prepared to meet the demand? These are questions which should receive careful consideration, as it is doubtful whether the gas industry could, on a remunerative basis, carry out such a scheme by means of low-pressure mains. It may therefore not be out of place to consider the possibilities of distributing gas over large areas by means of high-pressure mains.

The writer has been requested to bring this matter to the notice of the Institution, but he recalls that some six years ago he had the privilege of reading a paper before the Eastern Counties Gas Managers' Association, at Colchester, on the high-pressure system adopted by his Company. However, at the risk of repetition, he trusts the subject under review will prove, at this time, both interesting and useful.

In these days of high taxation and the popularity of the motor-car, the general tendency is for the people in our cities and large towns to move out into the country districts, and, having known the advantages of a gas supply, create for the country undertakings and smaller works a demand which, owing to the high costs prevailing and the difficulty of raising capital, they are unable to satisfy. It is therefore the large undertakings that must eventually provide ways and means of meeting these demands; and it is suggested that the distribution of gas at high pressure is worthy of serious consideration.

Prior to 1913, the area of supply of the Grays and Tilbury Gas Company consisted of 32 square miles, but by an Act of Parliament sought and obtained in that year, a further 130 square miles were added, which included 37 parishes not receiving a supply of gas, and 4 parishes supplied by small gas-works whose annual sales were as follows:

	Annual Sale of Gas, 1912.
(1) Stanford-le-Hope	5,861,000 c.ft.
(2) Laindon	1,208,400 ,,
(3) Billericay	4,934,300 ,,
(4) Rayleigh	5,462,900 ,,
Total	17,466,600 c.ft.

The 32 square miles of area referred to mainly constitute the district served by the Company by means of low-pressure mains; the added 130 square miles being the area supplied by means of the high-pressure system. The districts referred to are shown on the map appended.

The following is a description of the plant and mains laid down and in use:

At the works at Grays, two "Imperial" steam-driven double stage Ingersoll-Rand (No. 10 type) gas compressors are installed, each capable of compressing 25,000 c.ft. of gas per hour to 100 lbs. pressure (see fig. 1). The compressors receive a supply of gas taken from the outlet mains (18 in. diameter) of two gasholders, through a 10-in. pipe, which first enters a boiler shell, 11 ft. by 4 ft. 6 in., which acts as a container. The inlets and outlets of the compressors are 4 in. in diameter, and the gas being raised from 6 in. pressure to a maximum of 50 lbs. pressure is discharged into a 6-in. steel main emptying into a receiver (another boiler shell) of 1200 c.ft. capacity.

The outlet main from the receiver is 6 in. in diameter, and connected to a duplicate set of 6-in. high-pressure governors, of the dead weight ("Equitable") type, which control the pressure on the district mains. The pressure in the mains varies from 18 to 35 lbs. according to the demand. To ensure a constant pressure in the receiver, a $\frac{3}{8}$-in. pipe is fitted between the receiver and the steam control governors of the compressors, so that, as the demand for gas varies, the steam control governor regulates the speed of the compressors.

The adequacy of this system was put to a severe test during the war, when, during an air raid, the 4-in. high-pressure main at Laindon was severed by an anti-aircraft shell, the demand for gas being thereby considerably increased. The compressors took up the load at once, and maintained the pressure for two hours without causing any inconvenience to consumers in other parts of the district. At the end of this period it was possible to close an emergency valve, and so restore normal conditions.

A set of gauges records the pressure in the receiver and in the district mains.

MAINS.

From the outlet of the governors a steel main, 6 in. in diameter, carries the gas for a distance of 4 miles, at which point it is reduced to 4 in. in diameter, and branches off into two directions; one 4-in. main eastwards along the Southend Road passing through Stanford-le-Hope and Rayleigh to Hawkwell, and the other 4-in. main going northwards over Laindon Hills (400 ft. in height) and on to Billericay. Other mains of 2 in. diameter are taken off *en route* to supply villages and streets.

For instance, at Orsett, three miles from Grays, there are 4 miles of 2-in. main serving 145 consumers with an annual consumption of 3,366,700 c.ft. At Benfleet, 14

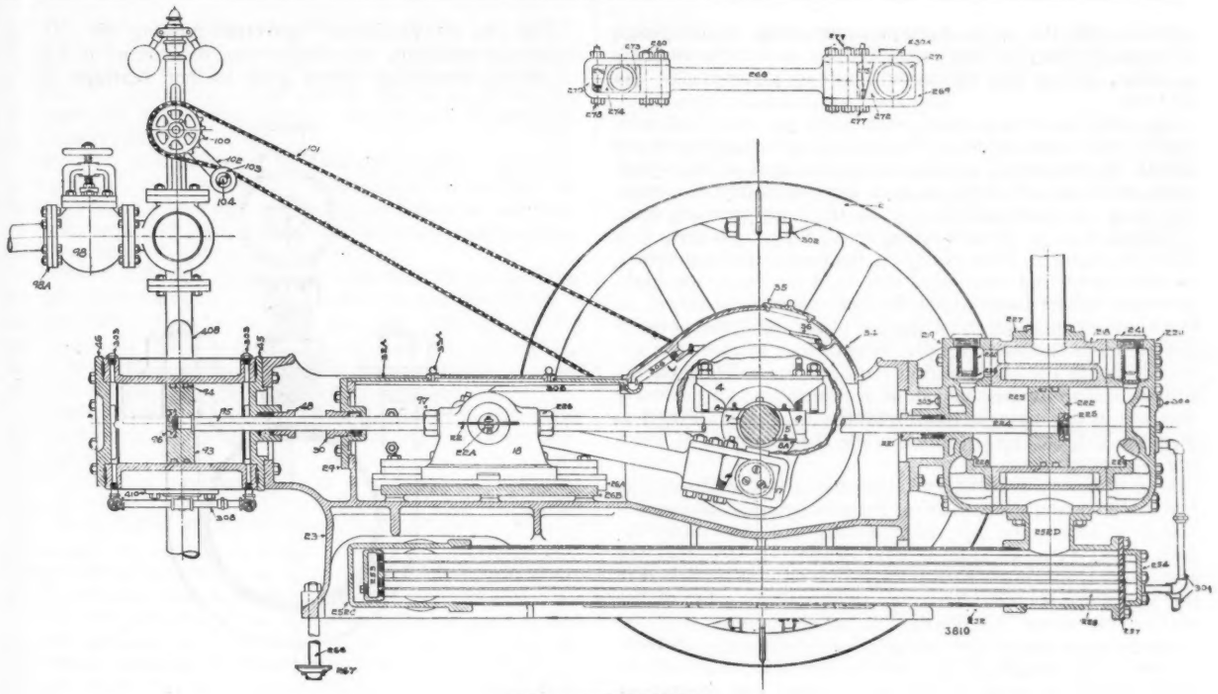


FIG. 1.—COMPRESSORS.

miles from Grays, 4 miles of 2-in. main serve 341 consumers with an annual consumption of 8,359,700 c.ft.

At approximately every 1000 yards, high-pressure valves are inserted in the mains, for use as occasion demands.

In order to pick up the low-pressure areas through which the high-pressure mains pass, the following sets of governors, in duplicate, are provided:

Stanford-le-Hope depôt	. . . . .	4-in. governors
Hadleigh	,, ...	3-in. ,,
Rayleigh	,, ...	6-in. ,,
Billericay	,, ...	6-in. ,,

The governors reduce the pressure in two stages, in the first instance breaking down to 2 lbs., and in the second to the required number of inches (see fig. 2).

The pipes used are made of mild steel wrapped and coated, having plain ends; no socket pipes of any kind being used. In making joints, the pipes are simply butted together and oxy-acetylene welded (see fig. 3).

The pipes as and when laid are tested to 100 lbs. pressure. The joints are protected by painting with dehydrated tar, and are wrapped with jute wrapping dipped in hot dehydrated tar and pitch.

When the work was carried out in 1914, the length and size of the pipes were as under—

Size of mains, inches	6	4	3	2	1	Total
Length in yards . .	6820	41,864	1816	28,038	351	78,889

totalling nearly 45 miles; and in addition to being tested in sections as laid, they were finally subjected to a test of 100 lbs. over practically the whole area. The cost, incl ding compressors, receivers, governors, and mains, amounted to £24,645 16s. 3d.

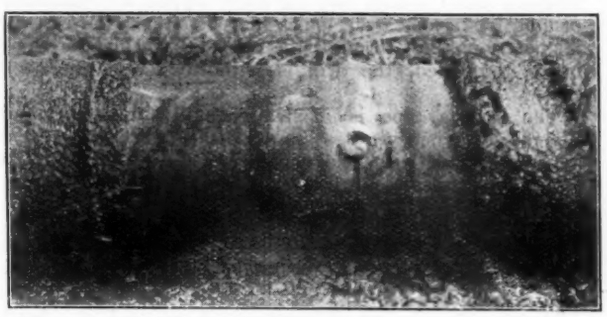


Fig. 3.—Welded Joints.

Various extensions of the high-pressure system have been carried out from time to time, including the replacing of the old low-pressure mains with 1½-in. and 1-in. high-pressure mains at Laindon, where there are 360 consumers, the consumption being over 10,000,000 c.ft per

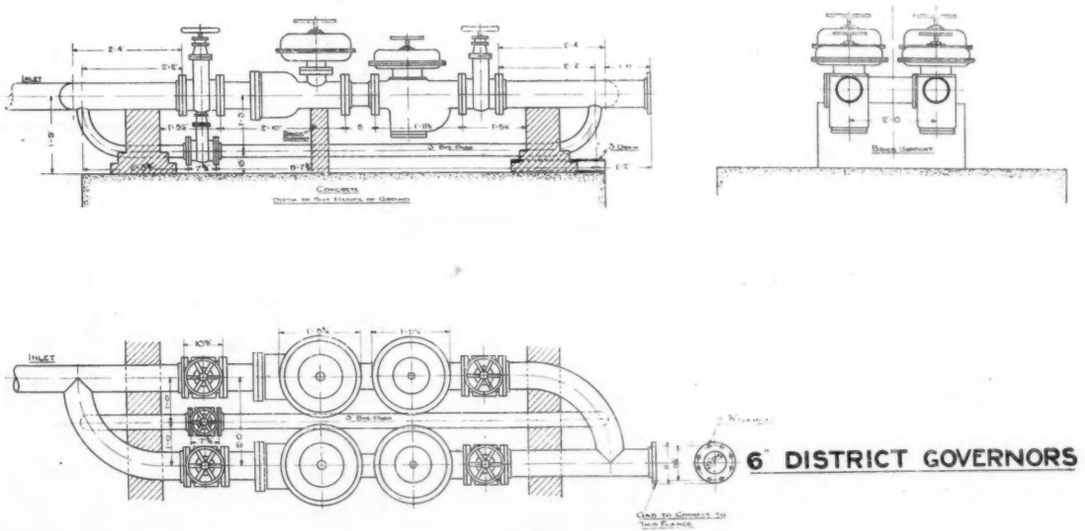


FIG. 2.

annum, and the 4-in. high-pressure main at Rayleigh through Hockley to Hawkwell, a distance of approximately 5 miles, where 164 consumers take 3,437,600 c.ft. per annum.

In addition, many small extensions of 2-in. and 1-in. mains have been made in different villages, notably in the South Benfleet area, so that the total length of high-pressure mains of all sizes is now approximately 60 miles, covering 22 parishes out of 41 in the high-pressure area.

When making branch connections for extensions, it is quite practicable, after notifying the consumers concerned, to shut down the section of the main between two high-pressure valves from which the branch is to be taken, as the quantity of gas in that section of the main, temporarily cut off from the main supply, is sufficient to meet the demand during the short period required for welding-on the branch. To obviate the risk of accumulating an explosive mixture in the main, a small quantity of gas is allowed to pass the valves, and is lighted while the operation of welding is in progress.

One distinct advantage of steel mains is the absence of fracture; no single case having been recorded. To emphasize this, some time ago, after a road had been under repair, about 13 miles from Grays, it was reported that the 4-in. steel trunk main to Rayleigh, which had been laid in the verge at some 2 ft. cover, was within 4 in. of the surface for about 100 yards. It would appear that the modern heavy traffic had actually forced the main up from its bed. Bf stripping the length, it was successfully lowered into its original position without any mishap of any kind.

In making a service connection from the high-pressure main, a clip of suitable size is used (see fig. 4).

The wrapping on the main is first removed, and the clip bolted on; a lead strip or gasket being placed between the clip and the main. A high-pressure gas cock is then screwed into the clip, and the main tapped with ordinary drilling tackle; the drill, which may be either $\frac{1}{4}$ in. or $\frac{3}{8}$ in. diameter, passing through the open cock. On the work being completed, the drill is withdrawn and the cock closed.

The service pipe is of steam quality, wrapped and coated, and whenever possible welded; otherwise screwed joints are made with lead and hemp, and tested to 50 to 60 lbs. pressure for not less than one hour, Milnes' main-testing "bubble" apparatus being used.

HOUSE GOVERNORS.

Inside the building a suitable house governor with mercury seal is fixed as under:

Messrs. Bryan Donkin governor $\frac{3}{4}$ in. or $\frac{1}{2}$ in., both passing approximately 250 c.ft. per hour, low pressure, requiring 4 ozs. of mercury in seal.

The No. 0 "Equitable" governor passing 60 c.ft. per hour, low pressure, and requiring $3\frac{1}{2}$ ozs. of mercury in seal.

The No. 1 "Equitable" governor passing 160 c.ft. per hour, low pressure, requiring 10 ozs. of mercury in seal.

All the above are fitted with leather seatings and a

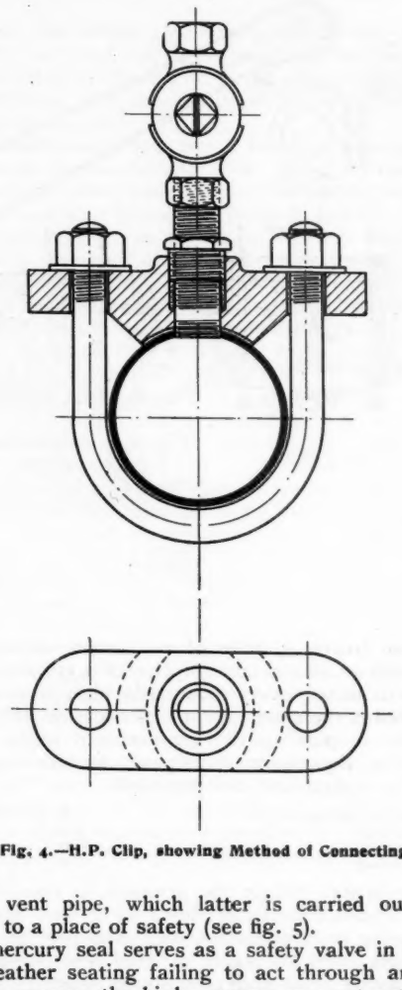


Fig. 4.—H.P. Clip, showing Method of Connecting.

suitable vent pipe, which latter is carried outside the building to a place of safety (see fig. 5).

The mercury seal serves as a safety valve in the event of the leather seating failing to act through any cause, and thus ensures the high-pressure gas not entering the meter. The outlet of the governor is connected to the meter in the ordinary way.

It is very important to see that the vent pipe referred to is kept open, and free from blockage of any kind. On an inspection of the vent pipes being made some few years ago, it was found that a number had become blocked; and upon investigation it was seen that a species of wild bee (osmia rufa) had built mud cells in the vent pipes and

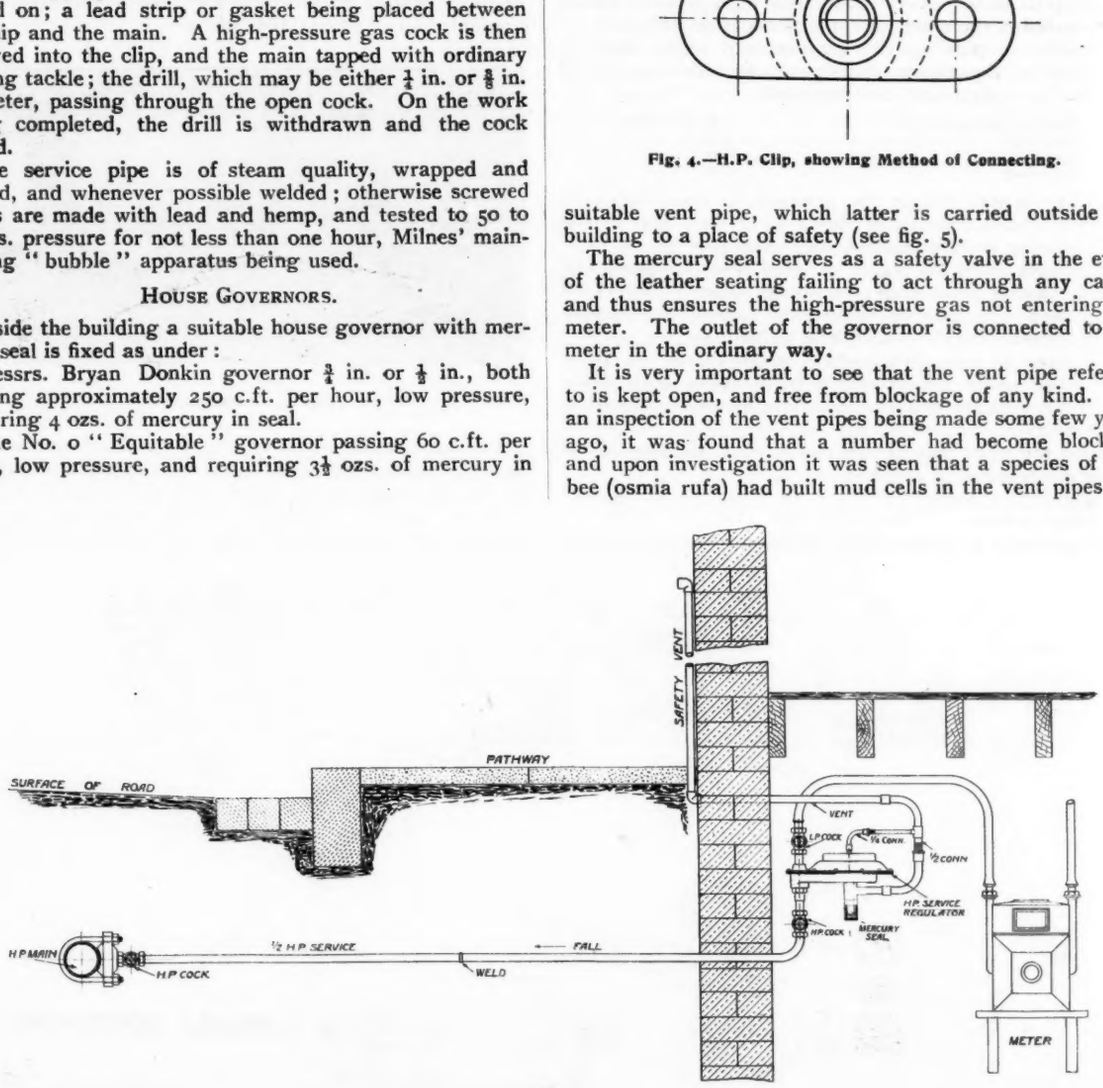


FIG. 5

laid its eggs, and also that the leaf cutting bee had in some instances chosen the same pipe and made cells in which eggs were laid, which in appearance were like the cocoon of a butterfly. The matter was of such interest that samples were accepted by the South Kensington Museum Authorities.

However, the difficulty has been overcome, and each vent pipe is now fitted with a malleable ¾ in. to ½ in. reducing socket, the small end being attached to the vent, and the large end being fitted with a perforated zinc disc with 195 holes to the sq. in.

The chief difficulty experienced with the system has been a slight accumulation of rust or foreign matter which is carried forward and deposited on the seating of the governors, in the case of the house governor causing the vents to blow, and the larger district governors to creep slightly, during the hours of low consumption.

A sample of the foreign matter removed from the governors was analyzed, and found to consist of 73 p.ct. of iron rust, 22 p.ct. of silica or fine sand, and a very slight trace of naphthalene. It would therefore appear that, in order to reduce the possibility of such accumulation, every care should be exercised in seeing that all pipes used are absolutely clean and free from internal corrosion before being jointed, and then well blown-out under good pressure, before finally being put to work.

As a safeguard against the possibility of getting excessive pressure in the low-pressure mains due to the governors creeping, an electric bell is fixed in the residence of each depôt inspector, and is brought into operation by the movement of a small column of mercury making contact and setting in action the bell, which operates should the pressure rise above 8 in.

With regard to the district governors, these were first placed in pits under ground in the main roads; but as the district is low-lying, considerable difficulty was experienced in giving them attention, owing to accumulation of water in the pits. They have since been removed to the several depôts, and fixed above ground, where they are easily accessible. The leather diaphragms of the district governors should be periodically oiled—say, every six months, and especially before the cold weather sets in—otherwise the leather is liable to become hardened. Neat's-foot, almond, or any vegetable oil may be used for this purpose.

The gas distributed through the high-pressure system during the first complete year (1915) after its installation amounted to 33,494,000 c.ft.; while for the year 1925 it was 93,093,900 c.ft. In addition, a 4-in. high-pressure main three miles in length is taken westward towards Rainham, where it is governed-down and connected into the low-pressure area, and supplies 1098 consumers. The total number of consumers on the high-pressure system is 4965; the total quantity of gas delivered being 119,626,900 c.ft., or 48 p.ct. of the total gas sales.

With regard to the possibilities of the system, below are given one or two instances:

(1) In the village of Orsett, at a spot 4 miles distant from the works at Grays, a ¾-in. service pipe 100 ft. in length, taken off the 2-in. high-pressure main supplying the village, serves a 45 H.P. gas engine used for the purpose of driving saw cutting machines.

(2) Some 10 miles from Grays, at the village of Vange, a 1-in. high-pressure main 1¼ miles long supplies no fewer than 31 consumers.

(3) Again, at Rayleigh, approximately 20 miles from Grays, a 1-in. service pipe, 70 ft. in length, successfully supplied gas to an 87 H.P. gas engine. Other instances of a similar nature could be given.

The mains are laid without any particular regard to levels, no water being found after the first mile. Any water occurring is easily removed by opening previously-arranged high-pressure cocks; the gas pressure in the mains at once driving out any condensate, which is collected in barrels.

The whole of the system is controlled by suitable governors as described; no gasholders being used. However, owing to the increasing demand for gas on this system, particularly in the east, it has been decided to erect gasholders at Stanford-le-Hope and Rayleigh. This will have the effect of relieving the high-pressure trunk mains of the increasing demand during the hours of heavy consumption, as the gasholders can take a supply for the low-pressure areas during the night and the periods of low consumption, the capacity of the high-pressure system thus being considerably increased.

Before deciding upon the erection of these gasholders tests were made as to the quantity of gas that could be delivered per hour to Stanford-le-Hope and Rayleigh, which depôts each have a small gasholder (one 12,000 c.ft. capacity, and the other 20,000 c.ft.), used for this purpose. The tests were somewhat limited, owing to the smallness of the holders available.

Test re Delivery of Gas at High Pressure from the Gas-Works, Grays, to Stanford-le-Hope Depôt.

Distance	5·8 miles.
Size of main	4 miles 6 in. in diameter. 1·8 miles 4 in. in diameter.
Connection between 4-in. high-pressure main and gasholder	175 ft. of 2-in. pipe controlled by 4 in. high-pressure valve.
Test taken	June 16, 1925.
Time	4.5 p.m.—4.25 p.m.
Specific gravity	0·53
Initial pressure at Grays	24 lbs.
Pressure on high-pressure main at commencement of test at Stanford-le-Hope	22 lbs.
Pressure at inlet of holder	49-tenths.
Time taken	20 minutes.
Pressure dropped on high-pressure main at Stanford-le-Hope to	13 lbs.
Quantity of gas delivered	8300 c.ft. = 24,900 c.ft. per hour.

Initial pressure at Grays gradually increased to 25 lbs. during test.

Test re Delivery of Gas at High Pressure from Gas-Works, Grays, to Rayleigh Depôt.

Distance	18 miles.
Size of main	4 miles 6 in. in diameter. 14 miles 4 in. in diameter.
Connection between 4-in. high-pressure main and gasholder	200 ft. of 2-in. pipe controlled by two 4-in. high-pressure valves.
Test taken	June 14, 1925.
Time	Between 12.20 a.m. and 1.12 a.m.
Specific gravity	0·56
Initial pressure at Grays	27 lbs.
Pressure on high-pressure main at commencement of test at Rayleigh	19 lbs.
Pressure at inlet of holder	30-tenths.
Time taken	52 minutes.
Pressure dropped on high-pressure main at Rayleigh to	9 lbs.
Quantity of gas delivered	12,000 c.ft. = 13,846 c.ft per hour

Initial pressure at Grays remained constant.

It should be remembered that in each case care had to be exercised to maintain the pressure on the high-pressure main so as not to interrupt consumers' supplies *en route*. If this had not been necessary, it is possible that better results would have been obtained.

Cost of Gas Compression.

It is difficult to arrive at the cost of compressing gas, as two 30 ft. by 8 ft. 6 in. boilers provide all the steam required for use on the works, including the compressors.

However, from a test made over one week, the total cost was as under:

	£	s.	d.
Fuel, 36 tons at 25s. per ton	45	0	0
80,000 gallons of water at 1s. 2d. per 1000 gallons	4	13	4
Wages (3 men)	11	5	9
	£60	19	1

The total quantity of gas made during the same period was 5,815,000 c.ft., and the cost of raising steam equals 2·51d. per 1000 c.ft. for all purposes. As full labour costs would be necessary whether gas were compressed or not, the sum of £11 5s. 9d. is left out of the calculation. Further, it is estimated that not more than 2/5ths of the steam raised is required for the compressors; and as 48 p.ct. of the gas made is delivered in this way, the cost per 1000 c.ft. is estimated at 1·70d., and with a standard calorific value of 460 B.Th.U. the cost per therm is 0·37d.

Calorific Power Tests.

Owing to the Company supplying gas by both low-pressure and high-pressure systems, the Gas Referees prescribe that two service pipes shall be taken from the mains, one from the low-pressure system and one from the high-pressure system, both pipes being accessible to the testing apparatus, it being left to the discretion of the Gas Examiner to test either or both of the gases, and, if both, the average of the two tests shall be the average for

the day. Appended are the results taken by the Examiner for the three months ended Dec. 30, 1925.

Official Test for Quarter ended Dec. 30, 1925.

Date.	Time.	L.P. Main.	Time.	H.P. Main.	Average.
Oct. 13 . .	2.30 p.m.	467·2	1.35 p.m.	467 8	467 5
,, 30 . .	4.50 ,,	470·7	5.50 ,,	474·0	472·3
Nov. 9 . .	1.30 ,,	465·6	12.35 ,,	460·0	462·8
,, 27 . .	12.15 ,,	467·5	1.10 ,,	468 7	468·1
Dec. 9 . .	3.20 ,,	466·8	4.10 ,,	465·1	466·0
,, 22 . .	6.20 ,,	468·6	5.30 ,,	466·7	467·6
,, 30 . .	4.50 ,,	471·2	5.50 ,,	472·0	471·6
Average		468·2		467·7	468·0

Note.—The high-pressure gas had previously been compressed to 50 lbs.

Further figures show tests made on the high-pressure system at Grays and also at the Rayleigh Depôt, some 18 miles distant. The gas was compressed to 50 lbs. pressure and delivered into the mains at 34 lbs., and afterwards reduced to 6 in. pressure at the outlet of the Rayleigh governors. List A shows the tests taken by the official calorimeter at Grays, and list B the tests taken at Rayleigh, by a similar apparatus.

Grays A. Official Calorimeter.		Rayleigh B. Laboratory Calorimeter.	
8/4/26,	1.50 p.m. 454	8/4/26,	6. 0 p.m. 460
,,	2.17 ,, ... 454	,,	6.30 ,, ... 459
,,	3.35 ,, ... 461	,,	7. 0 ,, ... 452
,,	4.10 ,, ... 472	,,	7.30 ,, ... 453
,,	4.47 ,, ... 464	,,	8. 0 ,, ... 454
,,	5.45 ,, ... 470	,,	8.30 ,, ... 461
,,	6.10 ,, ... 473	,,	9. 0 ,, ... 465
,,	6.30 ,, ... 470	,,	9.30 ,, ... 466
,,	7. 0 ,, ... 459	,,	10.30 ,, ... 465
,,	7.30 ,, ... 463	,,	11. 0 ,, ... 463
,,	8. 0 ,, ... 462	,,	11.30 ,, ... 472
,,	8.20 ,, ... 460	9/4/26,	7.15 a.m. 460
,,	9. 5 ,, ... 463	,,	8. 0 ,, ... 465
,,	9.24 ,, ... 478	,,	9. 0 ,, ... 469
,,	9.32 ,, ... 475	,,	9.30 ,, ... 470
,,	10.10 ,, ... 474	,,	10. 0 ,, ... 470
,,	10.40 ,, ... 463	,,	10.30 ,, ... 469
,,	10.55 ,, ... 462	,,	11. 0 ,, ... 472
9/4/26,	7.30 a.m. 458	,,	11.30 ,, ... 470
,,	8.28 ,, ... 470	,,	12. 0 noon 468
,,	9. 0 ,, ... 460	,,	1. 0 p.m. 467
,,	10.45 ,, ... 462	,,	1.30 ,, ... 470
,,	12. 0 noon 462	,,	2. 0 ,, ... 470
,,	1.39 p.m. 465	,,	2.30 ,, ... 477
,,	2. 0 ,, ... 466	,,	3.30 ,, ... 469
,,	2.31 ,, ... 468	,,	4. 0 ,, ... 463
,,	3.10 ,, ... 462		
,,	3.30 ,, ... 475		
Average of 28 tests = 465.		Average of 26 tests = 465.	

Note.—The tests were commenced at Grays about four hours earlier than at Rayleigh, in order to allow time for the gas to travel.

The following figures show the relative cost of mains up to 6 in. diameter, together with their capacity of delivery per mile, exclusive of cartage and labour in laying, as these must vary considerably even in one's own district :

Cast-Iron Pipes B.S.S. Class A, and Based on Current English Prices.

Size (Average Length, 9 Ft.).	Cost of Pipes per Yard.	Cost of Joints per Yard, Labour and Material.	Total Cost per Yard.	Gas Delivered per Mile at 6 in. Inlet and 5 in. Outlet Pressure, Pole's Formula.
	s. d.	s. d.	s. d.	C.Ft.
6 in. . . .	8 2½	1 8½	9 11	9088
4 in. . . .	5 1½	1 5	6 6½	3197

Note.—Jointer's wages taken at 1s. 10d. per hour, and labourer's at 1s. 5½d. per hour

Steel Pipes 7 and 8 Gauge Butt-Welded, Wrapped and Coated, Based on Current English Prices.

Size (Average Length, 18–20 Ft.).	Cost of Pipes per Yard.	Cost of Joints per Yard, Labour and Material.	Total Cost per Yard.	Gas Delivered per Mile at 20 Lbs. Inlet and 15 Lbs. Outlet Pressure.
	s. d.	d.	s. d.	C.Ft.
6 in. 7 gauge	11 4½	10½	12 3	72,576 Oliphant's formula 75,555 Pittsburg formula
4 in. 7 gauge	6 2½	6	6 8½	25,779 Oliphant's formula 27,358 Pittsburg formula
2 in. 8 gauge	2 9½	3½	3 0½	4,536 Oliphant's formula 4,864 Pittsburg formula

Note.—Jointer's wages taken at 1s. 8½d. per hour, and labourer's at 1s. 1d. per hour.

LIFE OF MAINS.

In the writer's opinion, the life of steel mains is largely dependent upon suitable protection being provided. In most cases the usual coating and wrapping is sufficient; but a further protection can be afforded by a mixture of dehydrated tar and sand, which will be found a good preservative. Pitch may be used for this purpose, if preferred.

SERVICES.

Comparative costs of services are as follows :

1.—*Low-Pressure Services 1 in. in diameter, 60 ft. in length, steam quality, exclusive of labour :*

	£ s. d.
60 ft. of 1-in. pipe, as above, at 4½d. per ft. .	1 3 1½
Fittings	0 4 5
One 1 in. low-pressure main cock	0 6 4
Total	£1 13 10½

2.—*High-Pressure Service 1 in. in diameter, 60 ft. in length, steam quality, wrapped and coated, exclusive of labour :*

	£ s. d.
60 ft. of 1-in. pipe, as above, at 6½d. per ft. .	1 11 3
Fittings	0 4 5
Two 1-in. high-pressure cocks	0 13 7
One house governor and vent	1 19 6
Mercury, 3½ ozs. at 4d. per oz.	0 1 2
One ¾-in. low-pressure cock	0 3 10½
Total	£4 13 9½

COMPLAINTS.

Comparative statement of complaints for the three months ended March 31, 1926, on the high-pressure and the low-pressure systems :

High Pressure.			Low Pressure.	
The Total Number of Consumers Supplied Direct from the High-Pressure Mains is 2153.			The Total Number of Consumers Supplied Direct from the Low-Pressure Mains is 9451.	
		P.Ct.		P.Ct.
House fittings . .	178 =	8·27	784 =	8·29
Meters	40 =	1·85	182 =	1·92
Cookers	90 =	4·17	353 =	3·73
House governors .	113 =	5·25	—	—
Services . . .	18 =	0·83	31 =	0·32
Total . . .	439 =	20·37	1350 =	14·26

It is regretted that figures are not available regarding loss of gas due to compression and leakage attributable to the high-pressure system. The gas unaccounted-for over the whole area for high and low pressure for 1925 was 9·74 p.ct. With regard to unaccounted-for gas on the high-pressure system, it is assumed that this cannot be excessive, for two reasons :

(1) The smallest leakage occurring on the system is at once readily located, owing to the high pressure in the mains.

(2) A further indication is that after the demand has ceased at night, one compressor is barely kept moving, and in addition the pressure in the main gradually backs up to the extent of 4 to 5 lbs.

COST OF UPKEEP OF COMPRESSORS.

The cost for general upkeep during the year 1925 was :

	£ s. d.	
Material	4 14 3	
Labour, oiling, and general repairs	26 6 6	
Oil	33 9 2	
Total	£64 9 11	or 0·128d. per 1000 c.ft. of high-pressure gas sold.

It will be fully appreciated that there is considerable difficulty in obtaining particulars and tests with regard to the system ; but the writer hopes that the information given will be of service, and at the same time submits that the results achieved fully justify his Company in the work undertaken in endeavouring to meet in the area served the growing demand by consumers who would not otherwise have the means of obtaining a supply of gas.

Discussion.

The PRESIDENT: Both the attendance here and the reception that the paper has received are indicative of the fact that this subject is a popular and appropriate one for this session. When I asked Mr. Sumner to be good enough to let us have this paper, I had this in view, of course; and I venture to believe that a man who has had the experience that Mr. Sumner has of the high-pressure distribution of gas must necessarily be a master of the subject. I asked him also to be so good as to go into all details such as would occur to him, with any suggestions I might have made myself; and I am extremely indebted to him for having taken me at my word in that respect, and for having put forward for the benefit of the members of the Institution such a very complete account of what he has done. The paper is now open for discussion.

Mr. WALTER HOLE (Torquay, Organizing Secretary of the Education Scheme): The subject we have had so admirably brought before us this morning is chiefly interesting to me, as I expect it is to most present, because it opens up two very different subjects—first of all the question of general policy, and then an interesting series of detailed operations. On the question of general policy, Mr. Sumner has told us—indeed, we are all only too well aware of it—that there has been a great migration of population from the towns into the country districts during the last few years. Thus people have been used to a supply of gas before moving outward; and therefore they are potential customers. In addition to this, the villagers—people living in the sparsely occupied territories to which they have moved—are also potential customers. On the other hand, as has been brought out in the paper, we are threatened within the next few years with having the whole countryside covered with a perfect cobweb of electric cables supplying electricity from large central stations. The question then arises: What are we as a gas industry going to do in the matter? We can obviously take one of two lines; we can sit still, hold our hands, and await events. This, it seems to me, is the way to misfortune. On the other hand, we can, by a well contrived and well adjusted extension of our distributing systems, particularly our high-pressure systems, cover the ground to which reference has been made. In this connection we ought to look at the situation, not as it is to-day, but as it will be in 10, 15, or 20 years' time. It seems to me that the true policy is to be first in possession. If we allow the electrical people, with their cobweb of electric cables, to go on attracting their consumers without the slightest opposition or competition, we shall find it extremely difficult to attract back again the consumers which are there, and which we might have had. The first in possession is evidently in a position of great advantage. The old doggerel "Thrice armed is he who hath his quarrel just, but four times he who gets his blow in first" applies to this as to many other things. So much for the question of general policy. There are two or three questions of detail to which I should like to refer, and there are one or two questions which I should like to ask Mr. Sumner. First of all, he tells us he has put down at the works certain compressors, and he describes the way in which those compressors are being supplied. I should like to ask whether he finds that he is getting any oscillation back again into his gasholders, which again, through the station governors, is affecting in any way the low-pressure system.

I was very interested indeed to learn that Mr. Sumner has adopted the butt-welded joint. As you know, throughout the country a large number—I suppose the larger proportion—of high-pressure gas mains are made with a sleeve joint welded on the face of the socket. When I was laying a high-pressure main some years ago, my own tentative experiments led me to doubt very much whether this was the strongest form of joint; and I put it to a real test. We were then laying a 9-in. high-pressure main. Unknown to the welder, I took out two joints, one a butt-welded joint, and the other a socket-welded joint. I cut out a 1-in. strip from each of those, and sent them to the Leeds University, and asked Prof. Goodman to test them for me. I was astounded at the result. The strip from the body of the main, 1 in. in width, stood a maximum tensile strain of 24·12 tons per sq. in. The butt-welded joint taken from that same joint stood a tensile strain of 20·37 tons per sq. in. A strip of pipe from a similar main, made with a socket-welded joint bore a tensile strain of 24·48 tons per sq. in., but the socket-welded joint itself bore a tensile strain of only 8·68 tons per sq. in., as against the 20·37 borne by the butt-welded joint. I considered those results were so extraordinary that I had better have them confirmed; so I took two other joints, again unknown to the welder, at random from a number of joints, and the result of the second test was as follows. The strip bore a tensile strain of 23·44 tons per sq. in., the butt-welded joint from the same pipe bore a strain of 23·12 tons per sq. in., or practically the same as the pipe itself. With the socket-welded pipe, the strip stood a strain of 28·18 tons, while the weld stood a tensile strain of only 9·11 tons per sq. in. This practically supported the results of the first test. I was not content with this; and I also tested two pipes for loading strain. I supported two 9-in. pipes on supports 28 ft. 6 in. apart, and gradually loaded them up at the centre; the joint, of course, being at the centre. I found that the butt-welded joint stood a loading strain of 17 tons 6 cwt. for a considerable time, while the socket-welded joint broke suddenly, almost as a glass tube might break, at 15 tons 3 cwt. I thought those figures would be of interest to the members of the Institution, because if a butt-welded joint is stronger than a socket-welded joint, what is the use of paying for the overload of material, *plus* the additional cost of rolling out the socket, *plus* the additional cost of increased weights for transport and handling?

There is another point of great interest to me in connection with the deposition of corrosion on the faces of the valves in both the district governors and the consumers' governors; and I should like to ask Mr. Sumner if he has found it necessary to filter his gas before passing it into the district governors, and if so whether he would give us the mesh of his filter gauze, and tell us how often he finds it necessary to clean it. Also, as bearing on the question of corrosion, whether, in addition to blowing-out his mains, in the first instance before starting to work, he finds it necessary periodically to blow-out his mains to clear them of corrosion. There is one other point. For many years those of us who have taken a great interest in high-pressure gas supply were haunted by the bogey of depreciation in gas value. You may remember that Mr. Botley's father at Hastings some forty years ago carried out some experiments, which have become classic, in which he showed that, so far as illuminating power is concerned, we might compress gas up to 200 lbs. per sq. in., and then let it expand back again, and the net loss is practically negligible—not more than 3 p.ct. It is interesting to find that the same thing holds in connection with calorific value.

Mr. F. H. ROBINSON (District Member of Council, Harrogate): The scheme described in the paper this morning is doubly interesting to me, because we have just completed a similar scheme to supply a district about 15 miles away, and we are about to enter upon a scheme of the same kind to supply a district 16 miles away in the other direction. The first scheme we have laid out as a high-pressure scheme, but have laid our mains sufficiently large, and at present are supplying the whole of the villages under the low-pressure system, because we are using the holders existing at the small works which we have closed. There is a point in this—namely, that we have been saved the expense of service governors, district governors, and other high-pressure fittings, and are able to supply the gas to the consumers in that area on rather more favourable terms than we could have done if we had started out with a high-pressure scheme at the commencement. At the same time we are providing for a greatly increased consumption in the future. There are one or two questions I should like to ask Mr. Sumner. First with regard to the question of depreciation in quality. I think it is remarkable that the calorific value at two points 15 miles apart should not differ. I have made tests on our high-pressure system, and have found, as he has, that the condensate takes place in the first mile or 1½ miles. This condensate when analyzed was equivalent to a drop in calorific value of about 5 B.Th.U. per c.ft. on a 460 B.Th.U. gas; beyond that we have not tested.

The PRESIDENT: What compressors do you use?

Mr. ROBINSON: We have Waller compressors. With regard to the first district mentioned, some 15 miles away, at a point 4½ miles from the gas-works there is a small holder. Nine miles beyond that there are two small holders supplying the districts previously supplied by the old works we have taken over. The effect of the first is to relay the pressure farther along the main. We find, after taking a series of pressure tests, that the pressure is remarkably uniform, as these holders come into play just at the peak loads. During the slack periods the pressure at our works is sufficient to fill them up for the next day. During the heavier hours of consumption, we put about 8 in. on the trunk main, and keep it on until about midnight; and the low pressure, when there is no draw on, is sufficient to keep these holders filled. I should like to thank Mr. Sumner for giving us the benefit of his extended experience on this interesting subject.

Mr. B. R. PARKINSON: I am very much interested in this paper by Mr. Sumner, for two reasons—the first because it deals with high-pressure distribution, and secondly, because I have some personal interest in part of the district covered by Mr. Sumner's operations. I had a good deal to do with the building of the new gas-works at Stanford-le-Hope, and the laying of the mains. I think Stanford-le-Hope was the first town laid entirely with steel mains in this country. I devised a scheme for high-pressure distribution to take over Laindon, which was almost identical with the scheme carried out by Mr. Sumner; but that is as far as I got with practical high-pressure distribution. Mr. Sumner came along like a hurricane, and swallowed us all up—Stanford-le-Hope, Laindon, then up north to Billericay, and east nearly as far as Southend. I call this real high-pressure distribution. There is a sense in which ½ lb. per sq. in. marks the difference between low-pressure and high-pressure distribution, but there is also a definite line of demarcation between high-pressure distribution up to 7, 8,

or 10 lbs. per sq. in. carried out by rotary compressors, and higher pressures such as 18 to 40 lbs. per sq. in. in the mains, as in this paper, carried out by piston compressors.

Some engineers are doubtful as to the practicability, on the ground of cost, of high-pressure distribution at pressures over 10 lbs. in systems of this kind. I do not know whether it would be asking too much of Mr. Sumner to put a question of this kind: If he were placed in charge of an undertaking of similar character to his own, but ten times its size, would he still advocate and carry out high-pressure distribution on the same lines as those laid down in his paper? As I have said, it is largely a matter of cost. There is the cost of compression, up-keep, depreciation, repairs, and also interest on capital in respect of the compressors, against the difference in cost in the first place of laying the mains, high-pressure and low-pressure. In the costs given in the paper, Mr. Sumner, after having mentioned the labour costs, eliminates them; but in a larger undertaking it would not be possible entirely to eliminate the labour costs. Speaking generally, I have concluded that 2 miles is the minimum limit for a decision between high pressure and low pressure. If you have 2 miles of main without any services on it, then you may begin to consider whether it is economical to compress your gas or to lay your mains large enough to take low-pressure gas. There are other considerations of course.

I have several questions to ask the author. On the outlet to the compressors, there are the storage cylinders fixed at 50 lbs. per sq. in. Are these cylinders partly for storage and partly for condensation of the gas? As you know, after condensation, the gas is reduced in pressure before it is sent out into the mains, so that the gas may be dry when passing through the mains. Therefore, are the cylinders for storage and for condensation? To which does Mr. Sumner attach the greater importance, for there is the extra cost of compression to 50 lbs. over and above the compression required for transmission through the mains? I think the instance given by the air-raid during the war, when the supply was kept up by this system, in spite of the mains having been fractured, is extremely interesting, and shows the foresight with which the system has been laid out for expansion and flexibility. I should like to ask another question about the rust or dust in the mains. Mr. Sumner indicates that the dust which accumulates in the governors, &c., is the initial rust and dirt in the mains when they are laid, and that if they were thoroughly cleaned out when laid, this would settle the question. I should like to ask him whether he believes there is still any internal corrosion going on in spite of the fact that the gas is relieved of its moisture. Has the high-pressure gas any effect in removing the oil and grease from the leather diaphragms of consumers' meters? Certain tests are given in the paper for the flow of gas through the mains; but it is not clear whether there were consumers taking gas *en route*. The paper indicates that there were; and I should like to ask Mr. Sumner if it would not be possible to make that test at night, when there is practically no consumption *en route*, and whether he could not give the drop in pressure where the 6-in. main concludes and the 4-in. main begins, so that this flow could be checked against various tables and formulæ.

While I am speaking of flow of gas, may I draw attention to the figures given in the table (cast-iron pipes, B.S.S., Class A), and ask Mr. Sumner whether some mistake or misprint has not been made. With regard to the gas delivered per mile at 6 in. inlet and 5 in. outlet pressure, by Pole's formula, I make it about half those figures—*i.e.*, about 4000 rather than 9000, and about 1400 rather than 3000 c.ft. If I am right, it would make a much stronger case for the following table in the paper. I have checked the other table also, and the high pressure would then be not nine times as efficient as the low pressure, but eighteen times. With regard to the unaccounted-for gas, may I just mention that one advantage of high-pressure distribution is that it is so easy to test your mains by drop of gauge, especially with valves placed about every mile. Knowing the storage capacity of the mains, and timing the drop of gauge, you can test the mains for leakage with extreme ease. Has Mr. Sumner considered placing high-pressure cylinders at the end of the mains, rather than having gasholders? It is, it may be remarked, noteworthy that on this high-pressure system they are going back to district gasholders, which is a slight modification of extreme high pressure. The same applies, I think, to the Mid-Kent Gas Company, who come next, I believe, in this country in extensive high-pressure distribution. They also are building one or two new gasholders in outlying districts, to relieve their storage. I should also like to mention one other matter with regard to Mr. Hole's remarks on welded joints. The comparison between the efficiency of the butt-welded and the sleeve-welded joint is, I think, largely a matter of the skill of the welder. If you have a highly-skilled welder, you can afford the luxury of a butt-welded joint; but if you are employing welders who are perhaps not so highly skilled, the sleeve-welded joint is more foolproof, if I may say so, although it may not be so efficient.

Mr. G. M. GILL (London): It seems to me that this paper is opportune. Mr. Hole referred to the probability of competition in the future, and it is to be hoped that the story of Mr. Sumner's work will encourage others to go and do likewise. Bearing upon the query that Mr. Parkinson has just put, I should like to ask Mr. Sumner whether he knows of the Horton sphere. It is a high-pressure gasholder, spherical in shape, made of steel plates, and stands on a light foundation. It is usually constructed for a pressure of 50 lbs. per sq. in. This Horton sphere is naturally much smaller for storing a given volume of gas as compared with the ordinary holder, and up to a size, I believe, of something like half-a-million it compares favourably in price. It seems to me that with a high-pressure system of this sort, high-pressure holders of that kind might prove useful. They are, in fact, being used largely in the United States with pressures up to 50 lbs. Another point is the type of main to be used. Some of us, I know, are a little bit nervous of the steel main, and we think of the possible effects of corrosion in the future. In the United States they use cast-iron mains with ordinary joints—the socket and spigot cast-iron pipe with lead joints—for much higher pressures than we are accustomed to employ here. It is becoming almost general practice to distribute gas at 10 lbs. per sq. in. through cast-iron mains. During my last visit to the States I met an engineer—the Engineer of the Davenport gas undertaking—who is using cast-iron mains for a distribution pressure of 25 lbs. The joints—and as far as I know they were made with a combination of cement and lead—were proving satisfactory. At another town in America, I came across an undertaking which was distributing all its gas at a pressure of 50 lbs. per sq. in. in steel-welded mains. To revert to the possibility of using cast iron, I had recently to investigate the question of rubber joints for cast-iron mains. A company supplying on the outskirts of Paris on a large scale—it is a very large undertaking—has used rubber joints on cast-iron pipes for the last twenty years exclusively. I had the opportunity of going into the matter, and the system seemed to me to be very satisfactory. With the rubber joints, a much higher pressure than usual could be employed with cast-iron mains. The life of the joints had proved satisfactory; and I examined a number that had been in use for upwards of twenty years, and had been taken out because of alterations to the mains. I thought these few points might possibly be of some interest in connection with Mr. Sumner's paper, which seems to be an admirable one, and one which will prove of great value to many members of the Institution.

Mr. H. D. MADDEN (Vice-President, Cardiff): In the first place I should like to add my congratulations to Mr. Sumner for his practical paper. I have had some experience of high pressure. In Cardiff we put down the first high-pressure mains about fifteen or sixteen years ago, and later we were faced with a growing district on the outskirts which had to be supplied with an ever-increasing quantity of gas. We had several difficulties; and the question of the main arose—whether it should be of steel or of cast iron. The old steel main which had been in existence for some years was opened-up and cut-out in several places; and we found that the wrapping and the sections of the pipe were as good as new. I should like to mention one trouble we have had, and which has been referred to by one or two other speakers—internal corrosion. We had it as severely, I think, as anyone. Petroleum was evaporated on the outlet of the compressor, and we find now there is an oily film running through these high-pressure mains, and the dust, if any is formed, is not carried forward. It simply drops into the bottom of the main, and the amount of dust found in the governors is practically negligible to-day. I think that if petroleum is sprayed, it will overcome the dust difficulty. However, we finally decided upon steel mains because we had to cross underneath the Great Western Railway main line at a level crossing, we had the Taff River to negotiate, we had a canal with a very awkward bridge, and then again we had to cut under four sets of the Great Western Railway and up a railway bank. After weighing all considerations, it was felt that steel would be safer for transmitting pressures up to 25 lbs. per sq. in. The engine is of the Belliss & Morcom type, and the compressor will deliver some ¾ million c.ft. at that pressure. The President has asked me about the cost of compressing and attendance. We have extended the exhauster house and placed the compressor in it, so that the attendance is part and parcel of the engine attendant's duties. Thus no additional cost should be incurred for this. I feel that with the growing outlying districts, the high-pressure system will have to be considered more than it has been in the past. We could only supply these districts by these means. There was no means of getting a low-pressure supply there, and the cost of high-pressure distribution was much lower than it would have been if we had adopted a low-pressure system with large diameter cast-iron mains. I think that, in view of the Government Bill, and with what we are faced, this important question of high-pressure transmission will have to receive a great deal more attention than it has done in the past. I, with others, thank Mr. Sumner for having brought the subject forward at this particular time.

Mr. W. J. SMITH (Bolton): Has Mr. Sumner had any experience of high-pressure mains with lead-wool caulked joints? I understand that such jointing is used up to 15 lbs., and

I wonder if Mr. Sumner, as the result of his experience, dare recommend it up to 50 lbs. There is another point. I understand that with welded mains, as with tram rails, no allowance is made for expansion and contraction; it is not considered necessary, though I know of tram rails in one season in our own town having two or three bad fractures, which, I take it, were due to variation of temperature. Where you are considering runs of mains of 3, 4, or 5 miles, would you suggest that an allowance should be made, and, if so, what allowance, for that expansion and contraction?

Mr. W. BENNETT (Mossley): In my case we supply about 55 p.ct. of our total output of gas through a high-pressure main—about 101 million c.ft—and the number of consumers supplied through that main is about 50 p.ct. of the total. I should like to ask Mr. Sumner if he has found any difference in the number of complaints from the consumers in his low-pressure district due to naphthalene, as compared with the number received from the consumers on the high-pressure main. In my case, during an epidemic of naphthalene complaints, I found that they practically all came from the low-pressure district, and that there was practically none from the district supplied from the high-pressure main. I had tests made, and found that the gas in the low-pressure main contained 2·82 grains of naphthalene per 100 c.ft. A test taken on the high-pressure main at the same time showed 1·98 grains per 100 c.ft. The other point I should like to deal with is the cost of compression.

The PRESIDENT: What compressors do you use?

Mr. BENNETT: I think they are Bryan-Donkin.

The PRESIDENT: What pressure do you use?

Mr. BENNETT: We compress up to 5 lbs. per sq. in. As to the details of the cost of compression, in twelve months we used twelve barrels of oil—320 gallons at 2s. 6d. per gallon, making £40. With regard to labour costs, we put three-eighths of the men's wages down to the cost of compression, because the rest of the time they spend on the exhausters and in the retort houses. We take it that three-eighths of the men's time is due to steam raising for compression, &c.; and this comes to £390. The amount of fuel put through the boiler during the twelve months was 1095 tons; and we estimate that two-fifths of this is due to the compressors—that is, 438 tons at 10s., which equals £219. For flue cleaning, the proportionate cost is £8, the repair of the compressor £48. The interest and sinking fund for the cost of the compressor was £64, making a total of £769, which amounts to 1·828d. per 1000 c.ft. It is remarkable that, though Mr. Sumner has taken out figures on a different basis, his cost comes out at 1·7d. He gives the cost for maintenance as 0·128d., which is exactly the same figure, to the third decimal place, as our cost which we got out about two years ago for a Board of Trade inquiry. Our figure was 1·828, and Mr. Sumner's figure is also 1·828.

Mr. THOMAS GLOVER (Past-President, Norwich): I should like to point out that the pressures are very different.

Mr. BENNETT: Yes. My pressure is 5 lbs. per sq. in., but Mr. Sumner's is much higher.

Mr. J. TAYLOR (Weston-super-Mare): I should like to refer to Mr. Hole's test on welded joints, and to say that at the time when the scheme at Mossley referred to by Mr. Bennett was put in, I made some similar tests. The tensile strength of the steel used in the mains worked out—I am speaking entirely from memory—at roughly 30 tons per sq. in. The strength of the butt-welded joint was in the neighbourhood of 20 or 21 tons per sq. in., which, I think, confirms Mr. Hole's figures. At the same time, I am sorry to hear Mr. Parkinson in the position of an apologist for inferior work in the welding of sleeve joints. I think that in the case of high-pressure distribution through steel pipes the greatest insistence must be laid on the highest type of workmanship. A question has been raised respecting lead-wool joints, and their suitability for high pressures. I made an interesting test to determine this point, and I found that lead-wool joints in steel mains can satisfactorily withstand a test pressure of 65 lbs. of air. That appeared to be the limit to which my joints would go; but when gas was used as the medium for testing, the same joint blew at approximately 50 lbs. per sq. in.

The PRESIDENT: I am afraid I must close the discussion, but before doing so I should like to make one or two observations, which I hope will be interesting to the members. First of all, I am pleased to hear Mr. Hole make the reference to my father. I would remind you, however, that his experiments were made with oil gas chiefly, and very high pressure was used, something like 200 lbs. per sq. in The results, of course, were surprisingly favourable, though they were carried out purely from the illuminating value point of view. I venture to suggest, however, with all diffidence in the presence of so many research chemists, that there is likely to be more depreciation with illuminating power than with the calorific value of gas as now manufactured on a more scientific basis. I think we may confidently assert that the depreciation in the calorific value of gas—properly compressed gas; it is a question of the type of compressor—is negligible. With regard to the high pressure to which Mr. Bennett referred, I venture to say that that is fairly low pressure. I do not call 5 lbs. per sq. in. any pressure at all. I have been accustomed to handle compressed gas for many years, and I always think of 100 lbs. or something of that kind. This is what I look upon as high pressure. Mr. Sumner, of course, has gone higher. Then we have to remember, with high-pressure systems, that it is possible to make use of a gasholder, as Mr. Sumner himself is doing; and this brings in other factors—viz., the factor of safety and the factor of simplicity. You can then transmit your gas at convenient pressures at such times when the load is not on; and it is altogether a most useful system. There is a small matter which may interest you as regards my practice at Hastings. We have recently taken over the Battle undertaking, where there are two small holders. Of course, we anticipate a large expansion in consumption; and what we have done is to lay a 6-in. main from our own canalization, and we are utilizing the holders there successfully on the local system. There is a valve at Battle, and we regulate it and keep these holders working. This is purely a low-pressure system, but the point is this that in the outside area where we are threatened with an extensive electrical competition we have in mind a scheme which will gradually develop into a complete canalization—into a ring system of mains; and the mains are being laid with this object in view. They are steel mains, but are not welded. I do not wish to say anything against welded mains. These particular mains are socket jointed with lead wool, because for many years I have found lead wool perfectly satisfactory. I always test at 50 lbs. per sq. in. pressure; and this pressure is maintained indefinitely. There is a difference between an air test and a gas test, as has been pointed out; but I have found that 50 lbs. per sq. in. is perfectly safe. The advantage you have with a system of this sort is that, provided the steel mains are properly laid and protected—that is a vital matter—you can extend indefinitely. It is only a question of the pressure you use for transmission. I will now call on Mr. Sumner to reply to the numerous questions which have been put, and which doubtless he will take as an indication of the satisfaction given by his paper.

Mr. SUMNER, replying to the discussion, said: I will try to be as brief as possible. Mr. Hole mentioned the possibility of oscillation due to compressing. When I started compressing I was rather nervous of doing damage to the low-pressure district, due to oscillation; but experience has proved that it does not affect the system in the least. I do not know whether it is because I happen to be well mained. I certainly record oscillation at the outlet of the governor, but the effect of this is not noticed by the consumers. Now that more gas is being compressed, we have two compressors continuously running, except during the night period, after midnight; but they keep a level oscillation which in effect practically comes down to no oscillation at all. With regard to jointing, I satisfied myself before setting out on high pressure that there was no object in using a sleeve joint when you can have a butt joint. I did not take any tensile tests, but I put it up to common-sense that, if a welded joint is going to be any use at all, a butt joint must be as efficient as a sleeve joint. The latter only adds to the weight of the pipe. I can understand using a sleeve when it is a question of bridging, and you want to get extra strength at that point; but the joint itself is a question of the weld, and I am convinced that you can get a better weld by butting two pipes together than you can by trying to weld the pipe and the socket. Whether I am right or not, I do not know; but at any rate I have had no trouble with any butt-welded joints during the whole of my experience with this type. I was asked whether I use filters. Probably I started on high pressure a little too early to think about filters. At any rate, I did not put them in, and we do not use them. I find little difficulty with regard to rust. The rust that we get is very fine; and if you take the trouble to inspect the governors, you will see the difficulty. I do not think any filter would really keep out these small particles of dust. If it gets on to the seating, the vent may blow. You will notice in the paper that I have given some particulars with regard to difficulties with governors; but these difficulties have chiefly arisen more recently, since I found it necessary to increase the pressures at certain periods. If, however, I can give a constant pressure on the high-pressure mains through the governors, then the defects of these governors are very small indeed. As you know, we have all been put to the test recently with regard to peak loads and peak hours; and we get a little more trouble then, because the varying pressure apparently carries some dust forward, which affects the seating of the governor. Even then I do not think the difficulties are excessive. Mr. Robinson mentioned the cost of high-pressure fittings in fitting-up consumers. So far we have been very successful in passing on a large proportion of the cost of these high-pressure fittings to the consumer. The people are so glad to get a supply of gas in these outlying parts that they do not mind spending a few pounds for that purpose. Moreover, as the service at the moment in most cases is purely lighting, we stick rigidly to our 30 ft. free, and the consumer pays the difference.

The PRESIDENT: No wonder you smile. [Laughter.]

Mr. SUMNER: With regard to decrease in calorific value, I was a little nervous before taking the tests—though I had

taken previous tests—with regard to this matter. I was glad, however, to find that the results came out as well as ever. I think it is rather remarkable that you can compress gas to 50 lbs. pressure, send it some 20 miles, and get practically the same result at the far end. I think our President has already explained this. Of course, we used to go for illuminating power, but now it is much more consistent to supply on the calorific value basis; and under these conditions you get a much better result for the consumer even at long distances.

Mr. Parkinson referred to steel mains and lead wool joints. The only lead wool joints we have on our system are those laid by Mr. Parkinson prior to our taking over Stanford-le-Hope. They have never given us any trouble. We get a few leakages; but you can knock these joints up satisfactorily. The pipes, however, have never been subjected to high-pressure tests. They are low-pressure pipes solely; and I was really surprised to hear our President say he had managed to get 50 lbs. pressure on a lead wool joint. I should not like to instal a high-pressure system with lead wool joints; and I think, from the results we have achieved, that the welded joint is a much more efficient job. When Mr. Parkinson asks me whether I would undertake a similar district, with ten times the amount of gas required, in the same way that I have dealt with the present area, I can say yes and no. There are so many things which enter into the question of distribution, and it is not a matter which one can easily answer offhand, and say that in any circumstances one would do exactly as one has done before. As a matter of fact, if I were doing that work again, I should carry out what I think would be a number of improvements. What I have endeavoured to do here is to present to you the installation we have adopted at Grays, and which has been working since 1913 very successfully with an increasing load. On the question of labour in steam raising, of course large works would have to have separate boilers for raising their power for compressing gas. In our case, of course, we use the same system; and I endeavoured to get at a figure, from our experience, which I thought was a fair and right one to put before you, and which I do not think can reasonably be called excessive, particularly when you try to bear in mind that people in outlying districts are much more willing to pay a little more for their gas than they are in large towns. The convenience of gas, they find, is far greater than they realized when they lived in large towns; and if you ask them to pay a little more for that convenience, they realize it is worth doing.

The question of storage cylinders has been mentioned by more than one speaker. I have had no experience of the Horton sphere. I have read some accounts of it in the American papers; but I felt that in dealing with our own district we could not do better than stick to something we knew, and which has given satisfaction for many years—the gasholder. Now that I am on the question of gasholders, a point has been raised by someone as to its being a retrograde step, but it is no retrograde step to use gasholders for this district, as I am now proposing to do. The point about the whole thing is this. At present the loads in these districts fluctuate a good deal, and it seems absurd to try to make your mains do all the work at one period, and then do nothing at other periods. Therefore, by the system I am adopting we shall be able to use the mains during the hours of no consumption, and utilize the gasholders during other periods. By this means we shall be able to pass a much larger quantity of gas through the mains in the 24 hours, probably three times; and this seems to me the right course to adopt. With regard to high-pressure cylinders at the works, the high-pressure cylinder at the works has a capacity of only 1200 c.ft., and cannot be called any kind of storage at all, and it was not installed with that object. I will explain why the cylinder was installed. When you are compressing gas, especially to high pressures, the gas is discharged into the mains with a heavy hammer-like blow, 50 lbs. every time. To get an even blow on the mains, and also to have a little backing-up of the governors, this high-pressure blow is put into the cylinder itself, not into the mains. There is no object in striking all the mains and joints throughout the district with high pressure when you can instal a small cylinder which collects some of the condensate—most of it, as a matter of fact. It was not put in for the purpose of storage, but it gives a level flow of gas through your governors. We can raise the gas to 50 lbs. pressure, and deliver it. You can easily see that, by adding another 10 lbs. to the pressure, it is possible to get an even pressure throughout the district.

With regard to rust in mains, I certainly think that the bulk of this was due to the fact that the mains were allowed to lie alongside the road while the work was being carried out. There were about 45 miles to put in, and we could not do it all at once. We were working at the rate of three miles a day with four gangs, but under these conditions I think the rust accumulated in the pipes. We are still having some difficulty as a result of this, which, however, is gradually decreasing. I have not found that high-pressure gas affects the leathers of meters. I have made several inspections of meters in the high-pressure districts, and I have been astonished at the amount of oil in the meters when they have been sent in for repair. The tests for delivery were taken in difficult circumstances; and I am afraid I cannot add to the paper with regard to this matter. I do not think I can take any responsibility for Pole's formula, though if I have made an error in working it out, I apologize. As to unaccounted-for gas, I do not think it is so easy to detect unaccounted-for gas on a high-pressure as it is on a low-pressure system, because, if you set out to test between the valves—which you have to assume are absolutely gastight, a state I have never yet found—you have also to take into consideration the fact that there may be a certain amount of consumption during the night. I do not think you can get a satisfactory test by sectionalizing the mains. One of the best tests is that which I have mentioned in the paper—viz., when the consumption has gone off, and one compressor has stopped, and the other is just turning over for backing-up the pressure in the mains themselves.

I think I have dealt with all the questions that have been asked except the one relating to the contraction and expansion of pipes. The pipes are laid practically at 2 ft. cover, and on the whole they are not subjected to very variable temperatures. I am a Southerner, and I do not know what happens in the North. In this part of the country, however, I do not think there is very much variation in temperature at 2 ft. cover in the ground. Moreover, if all the roads in the rest of England were like those in Essex, where they are all bends and twists, there would be enough natural bends to allow for any contraction and expansion that might take place.

RETORT SETTINGS
WILSON'S (CONT-INT.) VERTICALS
HISLOP'S HORIZONTALS
RENEWALS &
NEW BENCHES
GAS-WORKS ERECTED COMPLETE.
R. & G. HISLOP
Underwood House,
PAISLEY

The Second Edition is now Ready of
"Competition Points for Gas Salesmen."
By A. F. Bezant and N. S. Smith, B.Sc.
Price 7/6, post free.
WALTER KING, LIMITED, "GAS SALESMAN" OFFICES, 11, BOLT COURT, FLEET STREET, LONDON, E.C. 4.

HARRIS & PEARSON,
STOURBRIDGE, ENGLAND.
MANUFACTURERS OF
FIRE-CLAY GAS-RETORTS, FIRE-BRICKS, LUMPS, & TILES of Every Description.
GLAZED BRICKS AND PORCELAIN BATHS.

STOCK MARKET REPORT.

CONDITIONS on the Stock Exchange were mild and uninteresting last week. Prices fluctuated according to the prevailing rumours in the coal dispute, and at the close of the week these were very pessimistic. The possibility of a new conversion operation was mooted in some quarters, but conditions at the moment are considered to be too unfavourable. The result of the Portsmouth loan was better than was expected, only 16 p.ct. being left with the underwriters; but the success of the proposed New South Wales £4,000,000 5 p.ct. issue, even at the low price of 97, is regarded as problematical.

Rubber was the only market that showed any activity; prices rising with the improvement in the value of the commodity, and possibly on the good results reported by some of the companies.

The Gas Market was featureless. The number of transactions was about the same as the previous week; and, as will be seen in the Table, there were very few changes in quotations. The only home company's stock showing an appreciable increase was the British ordinary with a rise of 2 points; the remaining increases went to those companies operating abroad—viz., European ½ point, the 5 p.ct. debenture stock of the San Paulo Company, and three debenture stocks of the Primitiva Company, with increases of 2 points each. It will be noticed that some transactions were recorded at very low prices. This may be due to the rising price of gas; but rumours that inadequate standard prices are being made by the Board of Trade under the Gas (Amending Orders) Rules, 1926, may also have been a factor.

The following transactions were recorded during the week:

On Monday, Aldershot 73½, Bombay 20s. 3d., British 107, European 5⅝, 6, Gas Light and Coke 84½, 84⅝, 84¾, 85, 85⅛, 3½ p.ct. 61, 4 p.ct. preference 74½, 74⅝, Imperial Continental 125½, 126½, Primitiva 11s. 9d., 11s. 9⅜d., 12s., 12s. 1½d., San Paulo 6 p.ct. preference 8; 5 p.ct. debentures 48. Supplementary prices, Brighton and Hove 5 p.ct. debenture 95½, Gas Light and Coke 5 p.ct. debenture 99½.

On Tuesday, Commercial 3½ p.ct. 76¾, 3 p.ct. debenture 55½, European 6, Gas Light and Coke 84½, 84⅝, 84⅞, 85, Imperial Continental 125, Newcastle and Gateshead 3½ p.ct. debenture 67 13/16, Primitiva 11s. 9⅜d., 12s., 12s. 1½d., South Metropolitan 91⅜, South Suburban 5 p.ct. 96½, 97, Wandsworth, Epsom Stock, 104. Supplementary prices, Gas Light and Coke 5 p.ct. debenture 99⅜, Brentford 6 p.ct. 104, Hornsey 5 p.ct. preference 85.

On Wednesday, Bournemouth 4 p.ct. debenture 75, British 104, 106½, Commercial 4 p.ct. 78, 3½ p.ct. 74, 75½, 3 p.ct. debenture 55½, European 5⅞, 6, 6⅛, Gas Light and Coke 84¼, 84⅜, 85, 4 p.ct. preference 75½, Imperial Continental 125, 126½, Malta and Mediterranean 5½, Newcastle and Gateshead 3½ p.ct. debenture 67 13/16, Primitiva 11s. 9d., South Metropolitan 91¾, Tottenham "A" 107½, "B" 90, 91. Supplementary prices, Gas Light and Coke 5 p.ct. debenture 99½, Uxbridge 4 p.ct. debenture 71⅜.

On Thursday, British 106, 107, Cape Town 4½ p.ct. debenture 71, Commercial 4 p.ct. 77¼, 78¼, 3½ p.ct. 74, Continental Union 7 p.ct. preference 86, 87, European 6, Gas Light and Coke 84¼, 84½, 84¾, 85, 3½ p.ct. 60½, 4 p.ct. preference 74½, 75½, 76, Primitiva 12s., South Metropolitan 91½, 91¾, 6½ p.ct. debenture 101, Tottenham "B" 90, 91, Uxbridge 5 p.ct. preference 80. Supplementary prices, Bristol 4 p.ct. debenture 74, Gas Light and Coke 5 p.ct. debenture 99½.

On Friday, British 106 3/16, Cape Town 4½ p.ct. debenture 72, European 6, 6⅛, Gas Light and Coke 84¼, 84⅜, 3½ p.ct. 60¼, 4 p.ct. preference 76, 3 p.ct. debenture 58¾, 6 p.ct. Brentford debenture 104, 104½, Hastings and St. Leonards 5 p.ct. 90½, 90⅞, 3½ p.ct. 70, 70¼, Imperial Continental 125, Newcastle and Gateshead 3½ p.ct. 70, 70⅜, Plymouth 110, San Paulo 6 p.ct. preference 8 1/16, 8 3/16, South Metropolitan 91, 91½, 91¾.

Money rates in Lombard Street were higher for most of the week, but dropped slightly towards the close. The rate for old day-to-day loans, for the renewal of which borrowers had to pay up to 4½ p.ct., gradually fell, and new money was available at 3¾ p.ct. The applications for Treasury Bills were heavier than usual. The allotments averaged £4 12s. 9·75d. p.ct., which was nearly 2d. p.ct. less than the previous week. Discount rates were steady.

On the Foreign Exchange Market, French francs were weaker earlier in the day on Friday, but rallied towards the close, finishing at 174¼. Italian lire moved within narrow limits, and closed at 132⅛. The discount on forward Milan one month fluctuated considerably from 1⅝ to 7. Sterling on New York was easier, and finished at 4.85 15/16.

There was a sharp break in Silver on Chinese selling, and the price dropped to 27¼d. per oz. for cash. There were no gold movements, and the price remained nominally 84s. 11½d. per oz.

The Bank Rate is 5 p.ct., to which it was raised from 4 p.ct. on Dec. 3. Bankers' deposit rates are 3 p.ct. The deposit rates of the discount houses are 3 p.ct. at call and 3⅛ p.ct. at notice.

Issue.	Share.	When ex-Dividend.	Dividends. Prev. Hf.Yr.	Dividends. Last Hf. Yr.	NAME.	Quotations. Sept. 24.	Rise or Fall on week.	Transactions Lowest and Highest Prices.
£			%p.a.	% p.a.				
171,978	Stk.	Aug. 12	5	5	Aldershot 5 p.c. max. C.	72—75	..	73½
222,992	,,	,,	4	4	Do. 4 p.c. Pref.	65—70	..	..
1,551,868	,,	Apl. 1	6¼	6¼	Alliance & Dublin Ord.	85—90	..	..
374,000	,,	Ju.y 8	4	4	Do. 4 p.c. Deb.	67—70	..	..
300,000	1	May 6	1/7½	1/7½	Bombay, Ltd.	1 1/16—1 1/8	..	20/3
170,000	10	Aug. 26	8½	8½	Bournemouth 5 p.c.	11½—12⅝	..	..
500,000	10	,,	7	7	Do. B 7 p.c.	11½—12½	..	..
275,000	10	,,	6	6	Do. Pref. 6 p.c.	11—12	..	..
50,000	Stk.	June 24	3	3	Do. 3 p.c. Deb.	54—57	..	..
163,025	,,	,,	4	4	Do. 4 p.c. Deb.	74—77	..	75
214,740	,,	Aug. 26	12	12	Brighton & Hove Orig.	163—168	..	..
244,200	,,	,,	9	9	Do. A Ord.	125—130	..	..
1,387,500	,,	July 22	5	5	Bristol 5 p.c. max.	85¼—86¼a	..	..
855,000	,,	Mar. 18	8	7	British Ord.	105—110	+2	104—107
100,000	,,	June 24	7	7	Do. 7 p.c. Pref.	114—119	..	..
120,000	,,	,,	4	4	Do. 4 p.c. Red. Deb.	68—73	..	..
100,000	10	June 10	6	8	Cape Town, Ltd.	6½—7½	..	..
100,000	10	Apl. 22	4½	4½	Do. 4½ p.c. Pref.	6—7	..	..
150,000	Stk.	June 24	4½	4½	Do. 4½ p.c. Deb.	68—73	..	71—72
626,860	,,	July 22	6	6	Cardiff Con. Ord.	94—97	..	..
237,860	,,	June 24	7½	7½	Do. 7½ p.c. Red. Deb.	99—102	..	..
157,150	,,	Aug. 12	6½	5	Chester 5 p.c. Ord.	88—93b	..	..
79,185	1	Apl. 22	†2/-	†2/-	Colombo Ltd. Ord.	28/—30/-	..	..
24,495	1	,,	1/4⅜	1/4⅜	Do. 7 p.c. Pref.	20/—22/-	..	..
1,513,380	Stk.	Aug. 12	5⅛	5⅛	Commercial 4 p.c. Cap.	77—80	..	77½—78½
560,000	,,	,,	5/8/4	5/8/4	Do. 3½ p.c. Cap.	74—77	..	74—76½
475,000	,,	June 24	3	3	Do. 3 p.c. Deb.	55—58	..	55
800,000	,,	Oct. 8	—	4	Continental Union, Ltd.	27—32	..	..
200,000	,,	Mar. 4	7	7	Do. 7 p.c. Pref.	85—88	..	86—87
737,150	,,	Aug. 12	6½	6½	Croydon sliding scale	95—98	..	..
403,100	,,	,,	5	5	Do. max. div.	78—81	..	..
492,270	,,	Aug. 26	9	8	Derby Con.	107—109a*	..	..
55,000	,,	June 24	4	4	Do. Deb.	73—75c	..	..
209,000	,,	Sept. 16	5	5	East Hull Ord. 5 p.c.	84—87*	..	..
50,000	,,	June 24	5	5	Eastbourne 5 p.c. Deb.	91—96	..	..
1,002,180	10	Apl. 1	†6	†4	European, Ltd.	5½—6½	+⅛	5⅝—6⅛
18,738,960	Stk.	Aug. 12	4/17/4	5/1/4	Gas Light & Coke 4 p.c. Ord.	84—86	..	84½—85⅛
2,600,000	,,	,,	3½	3½	Do. 3½ p.c. max.	58—61	..	60½—61
4,157,020	,,	,,	4	4	Do. 4 p.c. Con. Pref.	74—77	..	74½—76
5,602,620	,,	June 24	3	3	Do. 3 p.c. Con. Deb.	58—61	..	58⅝
181,315	,,	,,	—	—	Do. 6 p.c. Br'tf'd Rd. Db.	100—105	..	104—101½
130,000	,,	—	10	10	Do. 10 p.c. Bonds.	..	..	..
42,000	,,	—	7½	7½	Do. 7½ p.c. Ilford Deb.	..	..	..
92,500	,,	Aug. 26	6½	6½	Hastings & St L. 5 p.c. Conv	87—92	..	90½—90½
258,740	,,	,,	5½	5½	Do. 3½ p.c. Conv.	66—71	..	70—70½
70,000	10	June 10	†10	†10	Hongkong & China, Ltd.	19½—20½	..	..
173,200	Stk.	Sept. 16	5	5	Hornsey Con. 3½ p.c.	67—69*	..	..
1,976,000	,,	May 20	10	‡10	Imperial Continental Cap.	123—128	..	125—126½
226,170	,,	Aug. 12	3½	3½	Do. 3½ p.c. Red. Deb.	68—71	..	..
235,242	,,	Aug. 12	6¼	6¼	Lea Bridge 5 p.c. Ord.	92—97	..	..
2,127,340	,,	Aug. 12	5¼	5¼	Liverpool 5 p.c. Ord.	79—80b	..	..
600,000*	,,	Mar. 18	7	7	Do. 7 p.c. Red. Pref.	102½—104½b	..	..
165,736	,,	Aug. 26	9	8	Maidstone 5 p.c. Cap.	112—117	..	..
63,480	,,	June 24	3	3	Do. 3 p.c. Deb.	53—58	..	..
75,000	,, 5	June 24	†6	†7	Malta & Mediterranean	5½—5⅝	..	5½
541,920	Stk.	May 20	†4	†6	Montevideo, Ltd.	79—82	..	..
2,061,315	,,	Aug. 12	5	5	Newcastle & Gateshead Con.	71—71¼d	+¼	..
360,929	,,	,,	4	4	Do. 4 p.c. Pref.	73—74d	..	..
529,705	,,	June 24	3½	3½	Do. 3½ p.c. Deb.	67½—68½d	−¾	..
15,000	,,	Aug. 26	11½	11½	North Middlesex 10 p.c.	151—156	..	..
91,530	,,	,,	8 2/20	8 2/20	Do. 7 p.c.	109—114	..	..
300,000	,,	May 6	9	7	Oriental, Ltd.	96—101	..	..
188,120	,,	June 24	7⅞	7⅞	Plym'th & Ston'house 5 p.c.	108—113	..	110
414,500	,,	Aug. 26	—	7/6/0	Portsm'thCon.Stk.4p.c.Std.	102—107	..	..
236,732	,,	,,	—	5/0/0	Do. 5 p.c. max.	78—81	..	..
2,289,909	1	—	—	—	Primitiva Ord.	11/6—12/6	..	11/9—12/1½
282,200	100	June 1	4	4	Do. 4 p.c. Red. Deb.	83—85	..	..
600,000	Stk.	July 22	4	4	Do. 4 p.c. Red. Deb. 1911	69—71	+2	..
180,305	,,	June 24	4	4	Do. B. Aires 4 p.c. Rd. Db.	69—71	+2	..
256,847	,,	,,	4	4	Do. R'r P'te 4 p.c. Rd. Db.	69—71	+2	..
150,000	10	Mar. 18	6	6	San Paulo 6 p.c. Pref.	7⅞—8⅛	..	8—8 3/16
125,000	50	July 1	5	5	Do. 5 p.c. Red. Deb.	46—49	+2	48
270,000	Stk.	Sept. 16	6	5⅜	Sheffield A	98—100c*	−2	..
419,968	,,	,,	6	5⅜	Do. B	98—100c*	−2	..
1,047,000	,,	,,	6	5⅜	Do. C	98—100c*	−2	..
90,000	10	June 11	4	—	South African	5—7	..	..
6,609,895	Stk.	Aug. 12	7	5	South Met. Ord.	90½—92½	..	91—91¾
1,895,445	,,	July 8	3	3	Do. 3 p.c. Deb.	57—60	..	..
734,000	,,	Sept. 16	6½	6½	Do. 6½ p.c. Red. Db.	100—102*	..	101
91,500	,,	Aug. 12	8½	8½	South Shields Con.	£14—116d	..	..
1,187,795	,,	Aug. 12	6½	6½	South Suburban Ord. 5 p.c.	96—99	..	96½—97
368,837	,,	June 24	5	5	Do. 5 p.c. Deb.	92–95	..	..
647,740	,,	Mar. 18	5	5	South'mpton Ord. 5 p.c. max.	77—80	..	..
121,275	,,	June 24	4	4	Do. 4 p.c. Deb.	68—73	..	..
250,000	,,	Aug. 26	7	7	Swansea 7 p.c. Red. Pref.	100—102	..	..
200,000	,,	June 24	6½	6½	Do. 6½ p.c. Red. Deb.	100—102	..	..
120,000	,,	July 22	7⅜	7⅜	Tottenham District A 5 p.c.	105—110	..	107½
882,275	,,	,,	5½	6½	Do. B 3½ p.c.	88—91	..	90—91
150,000	,,	,,	5½	5½	Do. 5½ p.c. Pref.	99—101	..	..
181,255	,,	June 10	4	4	Do. 4 p.c. Deb.	73—76	..	..
258,251	,,	Aug. 26	5	5	Tynemouth Con. and New	66 – 67d	+⅛	..
197,294	,,	Aug. 26	6⅝	6⅝	Uxbridge, Maidenhead, & Wycombe 5 p.c.	80—85	..	..
88,330	,,	,,	5	5	Do. 5 p.c. pref.	80—85	..	80
21,800	,,	,,	6⅜	6⅜	Do. 5 p.c. Maidenh'd	80—85	..	..
30,000	,,	July 8	8½	8½	Wandsworth, Wimbledon, and Epsom— Wandsworth A 5 p.c.	122—127	..	..
255,636	,,	,,	7	7	Do. B 3½ p.c.	102—107	..	..
412,450	,,	,,	5/19/0	5/19/0	Do. C and New	88—93	..	..
852,000	,,	,,	6⅜	6⅜	Wimbledon 5 p.c.	98—103	..	..
98,000	,,	,,	7⅜	7⅜	Epsom 5 p.c.	104—109	..	..
88,416	,,	June 24	3	3	3 p.c. Deb.	54—57	..	..

Quotations at :—a.—Bristol. b.—Liverpool. c.—Nottingham. d.—Newcastle. s.—Sheffield. *Ex. div. † Paid free of income-tax. ‡ Plus 8½ p.ct. p.a. special dividend.

NOTICES TO CORRESPONDENTS, ADVERTISERS, AND SUBSCRIBERS.

No notice can be taken of anonymous communications. Whatever is intended for insertion in the "JOURNAL" must be authenticated by the name and address of the writer—not necessarily for publication, but as a proof of good faith.

COPY FOR ADVERTISEMENTS for the "JOURNAL" should be received at the Office NOT LATER than TWELVE O'CLOCK NOON ON TUESDAY, to ensure insertion in the following day's issue.

Orders to Alter or Stop PERMANENT ADVERTISEMENTS should be received by the FIRST POST on Monday.

UNDISPLAYED ADVERTISEMENTS: Situations Wanted, Six Lines and under (about 36 words), 3s.; each additional Line, 6d. Situations Vacant, Apparatus Wanted and for Sale, Contracts, Public Notices, &c., 9d. per Line—minimum, 4s. 6d.

TERMS OF SUBSCRIPTION to the "JOURNAL."

		ONE YEAR.	HALF-YEAR.	QUARTER.
United Kingdom & Ireland	Advance Rate:	35/-	18/-	10/-
	Credit Rate:	40/-	21/-	11/6
Dominions & Colonies & U.S.A Payable in Advance		35/-	—	—
Other Countries in the Postal Union. Payable in Advance		40/-	22/6	12/6

In payment of subscriptions for "JOURNALS" sent abroad, Post Office Orders or Bankers' Drafts on London only are accepted.

All Communications, Remittances, &c., to be addressed to WALTER KING, LIMITED, 11, BOLT COURT, FLEET STREET, LONDON, E.C. 4.

Telegrams: "GASKING, FLEET LONDON." Telephone: Central 6055.

GAS PURIFICATION & CHEMICAL CO., LTD.,
PALMERSTON HOUSE, 34, OLD BROAD STREET, LONDON, E.C.2.

OXIDE OF IRON
FOR SALE OUTRIGHT, OR ON LOAN.

SPENT OXIDE
PURCHASED IN ANY DISTRICT.

Telegrams: "PURIFICATION, LONDON." *Telephone:* LONDON WALL, 9144.

"VOLCANIC" FIRE CEMENT.
Resists 4500° Fahr. Best for Gas-Works.
ANDREW STEPHENSON, Gresham House, Old Broad Street, LONDON, E.C. "Volcanism, London."

THE BRITISH GAS PURIFYING MATERIALS CO., LTD.,
99, LONDON ROAD, LEICESTER.
Telegrams: "BRIPURIMAT, LEICESTER." Telephone: LEICESTER 5096.
Solicit enquiries for:—
NATURAL BRITISH PURIFYING MATERIAL,
NATURAL HYDRATED OXIDE OF IRON,
FIRST QUALITY DUTCH BOG ORE,
BEST QUALITY BELGIAN BOG ORE,
"PREPARED" AND "UNPREPARED" ARTIFICIAL OXIDES,
SPENT OXIDE PURCHASED.
LONDON OFFICE: 84/85, NORFOLK STREET, STRAND, W.C. 2.
Telegrams: 'BRIPURIMAT ESTRAND LONDON." Telephone: CENTRAL 4545 & 4546.

"LUX" PURIFYING MATERIAL
THE PREMIER MATERIAL FOR GAS PURIFICATION.

THOS. DUXBURY AND CO.
SOLE AGENTS FOR ENGLAND, SCOTLAND, IRELAND, WALES AND THE COLONIES (except CANADA).
6, DEANSGATE, MANCHESTER. *Telegrams* "Darwinian, Manchester." *Tel. Nos.:* 3208-9 City.
PALACE CHAMBERS, WESTMINSTER, S.W.1. *Telegrams:* "Darwinian, Parl, London." *Tel. No.:* 3273 Victoria.

PATENTS, Trade Marks, Inventions Advice, Handbook and Consultations free. KING'S PATENT AGENCY LTD., Director B. T. KING, C.I.M.E., Regd. Patent Agent, G.B., U.S., and Can., 146A, QUEEN VICTORIA ST., E.C. 4, and 6, QUALITY CT. (next Pat. Off.), LONDON, W.C. 40 years' refs. 'Phone Cent. 682.

WE Specialize in Small Gas-Works and Solicit Inquiries for COMPLETE WORKS EXTENSIONS, and RENEWALS.
Penney & Porter (Engineers), Ltd.,
LINCOLN.
Established 1855.
Telegrams: Porter, Lincoln. Telephones: 266 & 211.

J. E. C. LORD (Manchester), Ltd., Ship Canal Tar Works, Weaste, Manchester. Pitch, Creosote, Benzols, Toluol, Naphtha, Pyridine, all kinds of Cresylic Acid, Carbolic Acid, &c.

J. & J. BRADDOCK (Branch of Meters Limited), Globe Meter Works, OLDHAM, and 45 & 47, Westminster Bridge Road, LONDON, S.E. 1.
WET AND DRY GAS-METERS, PREPAYMENT METERS, STATION METERS AND GOVERNORS.
REPAIRS RECEIVE PROMPT ATTENTION.
Telephones: 815, Oldham, and 2412 Hop, London.
Telegrams—"BRADDOCK, OLDHAM," and "METRIQUE, LAMB, LONDON."

MEWBURN, ELLIS, & CO.,
CHARTERED PATENT AGENTS AND TRADE MARK AGENTS,
70 & 72, Chancery Lane, London, W.C. 2.
Telegrams: "Patent, London." Phone 243 Holborn.
And 3, St. Nicholas Buildings, Newcastle-on-Tyne.

SULPHURIC ACID.
SPECIALLY prepared for the manufacture of SULPHATE OF AMMONIA.
SPENCER CHAPMAN & MESSEL, LTD.,
with which is amalgamated WM. PEARCE & SONS, LTD., 36, Mark Lane, LONDON, E.C. Works—SILVERTOWN.
Telegrams—"HYDROCHLORIC, FEN, LONDON."
Telephone—ROYAL 1166.

SULPHATE OF AMMONIA SATURATORS and all LEAD and TIMBER WORK in connection with Sulphate Plants.
We Guarantee promptness with efficiency for Repairs.
JOSEPH TAYLOR (SATURATORS), LTD., Chemical Plant Engineers, Blackhorse Street Mills, BOLTON.
Telegrams—"SATURATORS, BOLTON." Telephone 848.

WEIGHBRIDGES
FOR Motor Lorries and Railway Traffic can be seen erected at our works READY FOR DELIVERY. Inspection by your Engineer invited and a test by your Local Inspector of Weights and Measures before delivery. Every machine a High-Class Engineering Product and fully guaranteed.
CHARLES ROSS, LIMITED, SHEFFIELD.

GEORGE WILSON GAS METERS, Ltd. for GAS-METERS, ORDINARIES, SLOTS, AND REPAIRS.
Foleshill Road, COVENTRY.
Telephone: 596. Telegrams: "GASMETER," and at 268, Stockport Road, MANCHESTER.
Telephone: RUSHOLME 976. Telegrams: "GASMETER," and 46 & 47, Auckland Street, LONDON, S.E. 11.
Telephone: HOP 647. Telegrams: "GASEOUS LAMB."

APPOINTMENTS, &c., WANTED.

EXPERIENCED Lecturer and DemonSTRATOR in Cooking by Gas can give Local Demonstrations for Gas Undertakings.
Gas Engineers should apply now for vacant dates to Miss H. H. TUXFORD, M.C.A., "SOUTHBOURNE," BOTTESFORD, NOTTS.

YOUNG MAN requires permanent situation with Private Gas Company, Home or Abroad, as GAS METER REPAIRER. Thoroughly Experienced with all makes and sizes Tin Drys. Present situation 4½ years.
Address, No. 7689, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

OXIDE OF IRON.
SPENT OXIDE BOUGHT.
BALE & CHURCH, LTD.,
83, ST. MARY AT HILL, LONDON, E.C. 3. Phone: Royal 1484.

"TORTO" FIRE CEMENT.
BALE & CHURCH, LTD.,
83, ST. MARY AT HILL, LONDON, E.C. 3. Phone: Royal 1484.

"KLEENOFF," THE COOKER CLEANSER.
Tins for Sale to Consumers.
In Bulk for Works Use.
(*See also advertisement, p. 731.*)
BALE & CHURCH, LTD.,
83, ST. MARY AT HILL, LONDON, E.C. 3. Phone: Royal 1484.

APPOINTMENTS, &c., VACANT.

APPLICANTS for the Position of ColLECTOR at Kildwick are THANKED; the VACANCY BEING NOW FILLED.

BOROUGH OF NELSON.
(GAS DEPARTMENT.)
TECHNICAL Assistant wanted, with Laboratory, Drawing Office, and Engineering Experience. Commencing Salary, £300.
Applications, stating Age, and giving full Particulars of Training and Experience, to be lodged with the undersigned not later than the 15th of October, 1926.
JAMES MITCHELL, Engineer and Manager.
Gas Offices, Nelson, Sept. 27, 1926.

WANTED — First-Class Structural ENGINEER residing in or near Leeds if possible, to Inspect Manufacture of Gasholder for shipment abroad. To start duties about end October.
State Experience, Qualifications, and Salary required, to Box K.R., care of DAVIES & Co., 95, BISHOPSGATE, LONDON, E.C. 2.

WANTED — Meter Inspector and ColLECTOR accustomed to Ordinary and Slot Meters.
Enclose three Testimonials and state Salary to BATHGATE GAS COMPANY, LTD., BATHGATE.

RETORT Setter Wanted. Must be Experienced in both Vertical (Woodall-Duckham) and Horizontal types of Retorts. Permanent position to Competent Man. Present rate of pay 1s. 9d. per hour.
Apply, stating Age, whether Married or Single, to Mr. A. COOK, ENGINEER AND MANAGER, GAS DEPARTMENT, WARRINGTON.

PLANT, &c., FOR SALE & WANTED.

PLANT FOR SALE.

TWO 16 ft. sq. Dry-Lute Purifiers. Two 8 ft. square Purifiers, Valves, Connections, Lifting Gear, &c.
Modern Steam Engines and Gas Exhausters.—20,000 and 15,000 c.ft. capacity.
Rectangular Station Meters.—Fitted with new drums, 10,000 and 15,000 c.ft. capacity.
"Livesey" and "Cripps" Patent Washers.—150,000 and 200,000 c.ft. capacity.
One Cornish Boiler.—5 ft. dia. by 12 ft. long, 80 lbs. pressure, with all Fittings.
Three Tar and Liquor Storage Tanks.—6 ft. 6 in. dia. by 30 ft. long.
Full Detailed List sent on Application.
Low prices for Modern Overhauled Plant. Erection included if desired.
Firth Blakeley, Sons, & Co., Ltd.
(Second-hand Plant Dept.),
Vulcan Ironworks, Church Fenton, Leeds.
Telephone: 14, South Milford. Telegrams: Blakeleys, Church-Fenton.

(*Continued on p. 906.*)

INSTITUTION NUMBER.

GAS JOURNAL

LIGHT ✦ HEAT ✦ POWER ✦ BYE-PRODUCTS

[Founded in 1849 as the "Journal of Gas Lighting."]

VOL. CLXXV. No. 3306.] LONDON, SEPTEMBER 29, 1926. [78TH YEAR. PRICE 2s.

JOHN HALL & Co. (OF STOURBRIDGE), LTD.,

CONTRACTORS TO HIS MAJESTY'S HOME & INDIAN GOVERNMENTS.

STOURBRIDGE.

ON ADMIRALTY AND WAR OFFICE LISTS

MANUFACTURERS OF

GAS RETORTS, HORIZONTAL, INCLINED, and VERTICAL.

SPECIAL BRICKS, TILES, AND BLOCKS FOR ALL MODERN GAS SETTINGS, AND EVERY DESCRIPTION OF FIRECLAY GOODS.

REFRACTORY INSULATING BRICKS

FOR

RETORT BENCHES, WASTE HEAT MAINS, BOILER SETTINGS, ETC.

SPECIAL FEATURES: LOW CONDUCTIVITY.
HIGHEST REFRACTORINESS.
GREAT MECHANICAL STRENGTH.

SOUTH OF ENGLAND AGENT:
C. VERNON, 182, SHAFTESBURY AVENUE, SOUTHEND-ON-SEA, ESSEX.

GAS MAINS
in
Weldless Steel

A Weldless Steel Gas Main means

Economy in cost of laying, due to the longer lengths which reduce the number of joints, and the saving in transit and handling costs owing to the lighter weight.

Lower maintenance costs. The saving in leakages, due to the fewer and more efficient joints, and to the fact that the steel main is unbreakable, has proved that they cost very much less to maintain than cast iron.

Greater delivery capacity due to the reduced thickness of the tube and the smoothness of the bore, which considerably reduces friction.

Bending on site is possible, thus avoiding a large number of specials.

Municipal Authorities and Contractors are invited to send for full particulars from

BROMFORD TUBE Co LTD
BIRMINGHAM

COAL SHORTAGE

Economise Fuel

by installing

"RETRIEVER" RECOVERY PLANT

Nearly 40 Installations supplied, all giving complete satisfaction.

Suitable also for Coke Breeze Washing.

From numerous tests made the amount of good coke contained in Pan Ash varies from 35 to 45 per cent.

Illustrated Pamphlet and full particulars on application.

G. WALLER & SON, LTD.,

Phœnix Iron Works, Stroud, Glos.

Telegrams: "WALLER, BRIMSCOMBE." *Telephone:* BRIMSCOMBE 10.

London Office: 149-150, PALACE CHAMBERS, WESTMINSTER, S.W.1. *Telephone:* VICTORIA 9476.

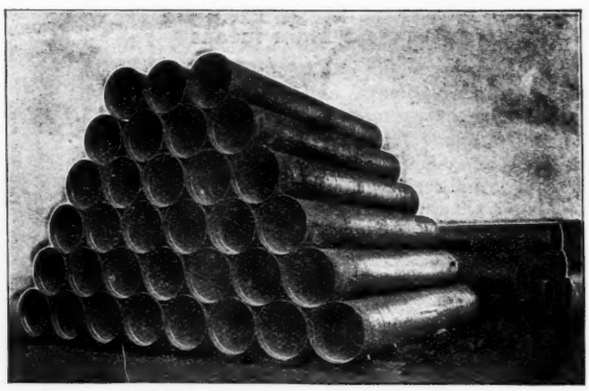
Agents for Scotland: D. M. NELSON & CO., 20, West Campbell Street, GLASGOW.

STEEL PIPES WELDED & RIVETTED.

For GAS, WATER & OTHER PURPOSES.

With Socketted, Flanged or other Type Joints.

DIMENSIONS SUPPLIED ARE 14" DIAMETER AND UPWARDS, AND LENGTH 18 TO 26 FEET.



Steel Pipes supplied to Vancouver Gas Co.

Advantage over Cast Iron Pipes: Saving in Cost of Transport and Laying, owing to less Joints, and in Repairs as unaffected by Variations in Temperatures.

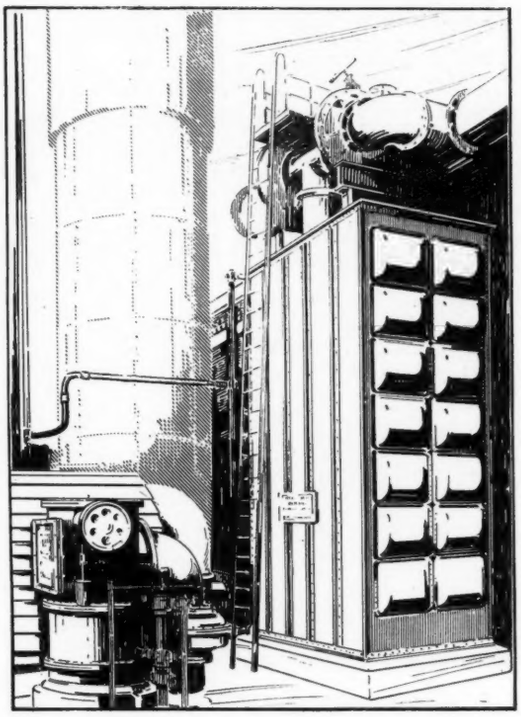
SEND YOUR ENQUIRIES TO

THOMAS PIGGOTT & CO., Limited,

SPRING HILL, BIRMINGHAM.

Telegrams: "Atlas, Birmingham." Telephone: Northern 1222. LONDON OFFICE: 63, QUEEN VICTORIA ST., E.C.4.

The New Holmes "Super Type" Condenser



"Remarkably efficient from the point of view of both condensing area and water consumption.

"It has given the greatest satisfaction since it was installed."

F. C. BRIGGS, Esq., A.M.Inst.C.E.

Presidential address to the Midland Association of Gas Engineers and Managers, March 11th, 1926.

ORDERS
RECENTLY COMPLETED OR UNDER CONSTRUCTION

Gas Works:

SOUTHAMPTON
GAS LIGHT & COKE CO., Fulham
BOURNEMOUTH (3 repeat orders)
SWANSEA
CHESTERFIELD
CAMBRIDGE
TORQUAY
BRIGHTON
WEYMOUTH
READING
BRIERLEY HILL
DUDLEY
OTLEY
L. ASKEW & SON, Godalming
WOLSTANTON
BATH
YORK
MANCHESTER (Partington)
CHRISTCHURCH, N.Z.
COVENTRY
LANCASTER

HOLMES
SUPER TYPE CONDENSERS

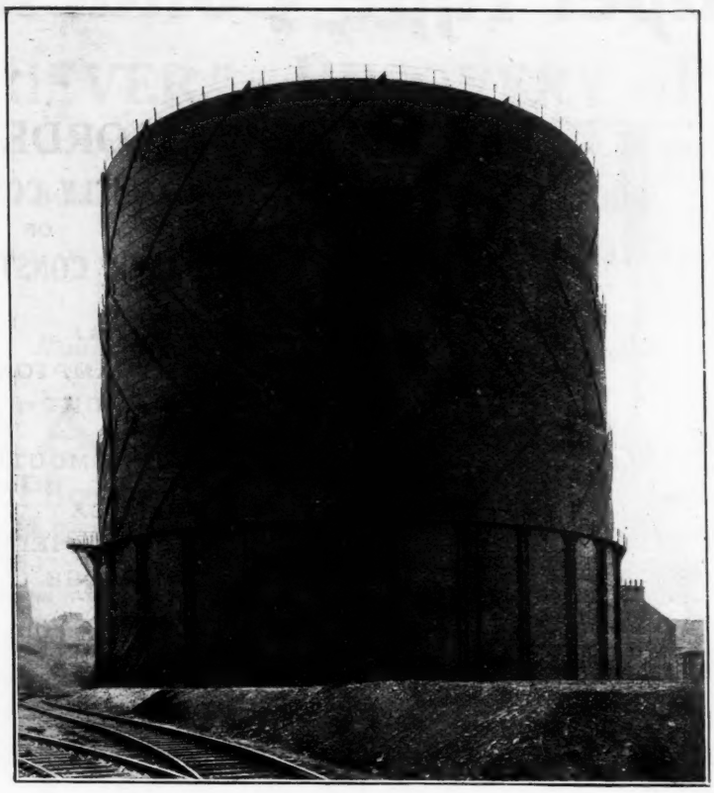
BRITISH FURNACES LTD. *ASSOCIATED FIRM.*

THE BARROWFIELD IRON WORKS, LTD.,

GAS ENGINEERS AND CONTRACTORS,

Telegrams: "GASOMETER GLASGOW."
Phone No. 777 BRIDGETON (3 Lines).

GLASGOW.



1¼ Million 3-Lift Spiral Holder in Steel Tank.

GASHOLDERS and TANKS of any size or type.

CONDENSERS—Water Tube, Annular or Open Atmospheric.

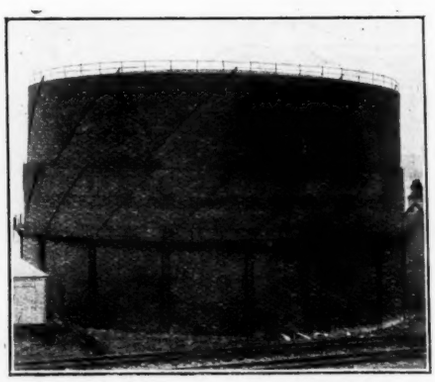
TOWER SCRUBBERS.

PURIFIERS—Water or Dry Lute Cast Iron or Ferro-Concrete Boxes.

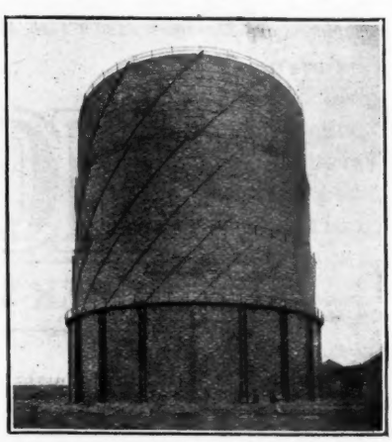
OIL and CHEMICAL WORKS PLANT.

STRUCTURAL WORK of every description.

STEEL RIVETTED PIPES.



Spiral Gasholder in Steel Tank, 120 ft. diameter.



Spiral Gasholder in Steel Tank, 107 ft. diameter.

London Office: 6, LITTLE BUSH LANE, CANNON STREET, E.C.4.

Sugg's New "PROMENADE" LAMP

Any type of Automatic Controller can be supplied with the lamp.

—more artistic and more efficient than the square lamp, yet quite as cheap.

The popular lamp for new lighting schemes.

FULL DETAILS FROM—

William SUGG & Co., Ltd., Ranelagh Works, Chapter St., WESTMINSTER, S.W.1

RATEAU TURBO
Gas Exhausters, Blowers & Fans

DRIVEN BY

Steam Turbine, Gas Engine, Electric Motor, or Belt.

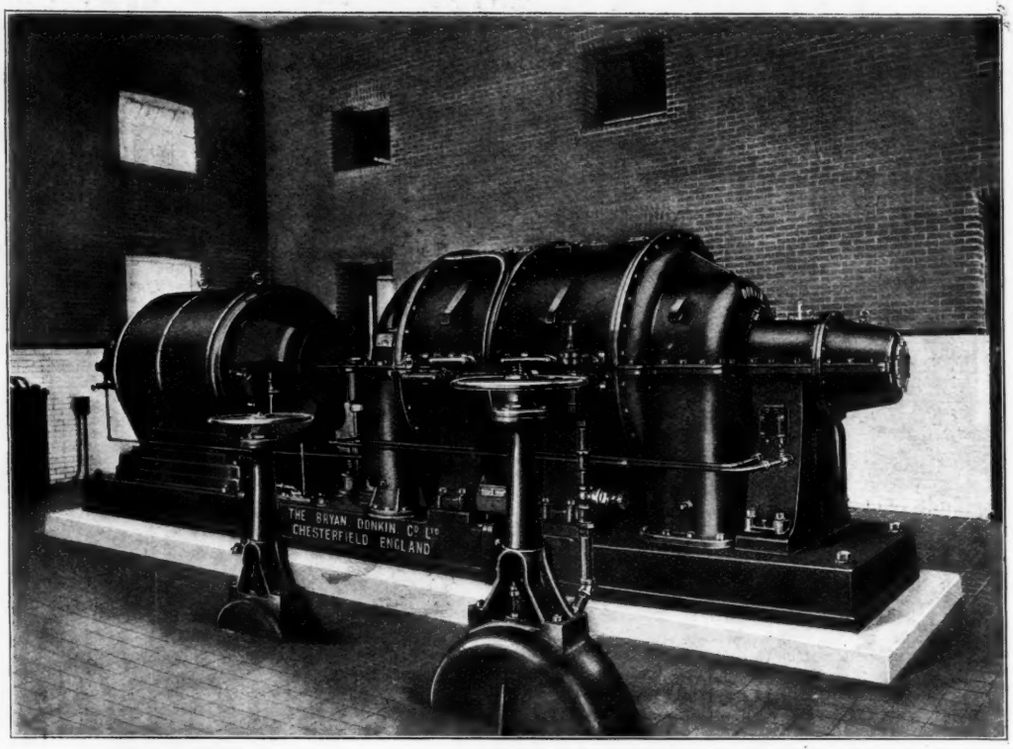


FIG. No. 775.

The above is a view of a Rateau Seven-Stage Turbo Compressor driven by a 1,500 B.H.P. Electric Motor, to pass 1,000,000 cubic feet of gas per hour at 3,750 r.p.m. against 15 lbs. pressure —supplied to the Montreal Light, Heat & Power Co.

We have supplied and have on order **211** Machines of total capacity of **117,084,166** cubic feet per hour.

HIGH PRESSURE GAS DISTRIBUTION & BOOSTING
:: :: :: ***A SPECIALITY.*** :: :: ::

THE BRYAN DONKIN COMPANY, LTD.,
CHESTERFIELD.

BRING YOUR PLANT UP-TO-DATE

— *with the* —
"MENNO" MODERN METHOD *of* **LUBRICATION**

Annual costs for lubricants are reduced by 75%. Annual costs for renewals and repairs, due to inefficient lubrication, are reduced by 85% by using—

"MENNO"

COMPRESSED AIR GREASE CUPS

The compressed air in the top chamber responds precisely to the requirements of the bearing under all conditions. Adjustment is required at long intervals only, during which the action is entirely automatic. There is no waste. Bearings are sealed against dust and grit, and perfect lubrication ensured. The use of a "MENNO" is a

GUARANTEE *of* EFFICIENCY & ECONOMY

Pressed from steel or brass and with standard shanks, they are easily fitted to all classes of existing or new machinery.

If not already using "Menno's" give them a trial. Send for a sample.

THE MENNO COMPRESSED AIR GREASE CUP CO., LTD.,
Leeds Place, Tollington Park, London, N.
Telephone: North 1786.

A Fletcher Gas Grate in a distinguished setting.

Photograph taken in the drawing-room of Viscountess Gort's residence, showing Fletcher Russell & Co.'s "Boscobel" Gas Grate.

FLETCHER RUSSELL & CO., Ltd., 4, Berners Street, London, W.1,
and PALATINE WORKS, WARRINGTON.
(Radiation Ltd., Proprietors.)

SPIRAL GASHOLDER SPECIALISTS.

DURING **1926** HOLDERS UNDER CONSTRUCTION AND COMPLETED BY **R. & J. D.** WILL HAVE STORAGE CAPACITY **EXCEEDING 28 MILLION CU. FT.**

MANCHESTER 5 MILLION.

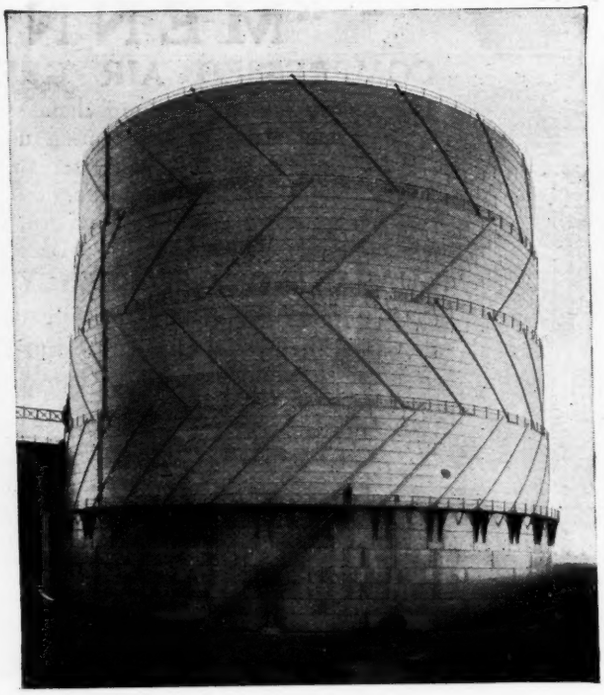
SMETHWICK 3½ MILLION.

NORTHAMPTON 2 MILLION.

WELLINGTON (N.Z.) 2 MILLION.

KINGSTON 1 MILLION.

ELLESMERE PT. ⅓ MILLION.



DUBLIN 3 MILLION.

FULHAM 4 MILLION.

BLACKBURN 2 MILLION.

CARLISLE 2 MILLION.

PERTH 1½ MILLION.

BRIGHTON (AUS.) ¾ MILLION.

SPALDING ½ MILLION.

MANCHESTER

STEEL TANK, 213 FT. DIA. × 41 FT. 6 IN. DEEP, FOR 5 MILLION SPIRAL HOLDER.

The Illustrations above are to designs by W. NEWBIGGING, Esq., M.I.C.E.

R. & J. DEMPSTER, LTD.

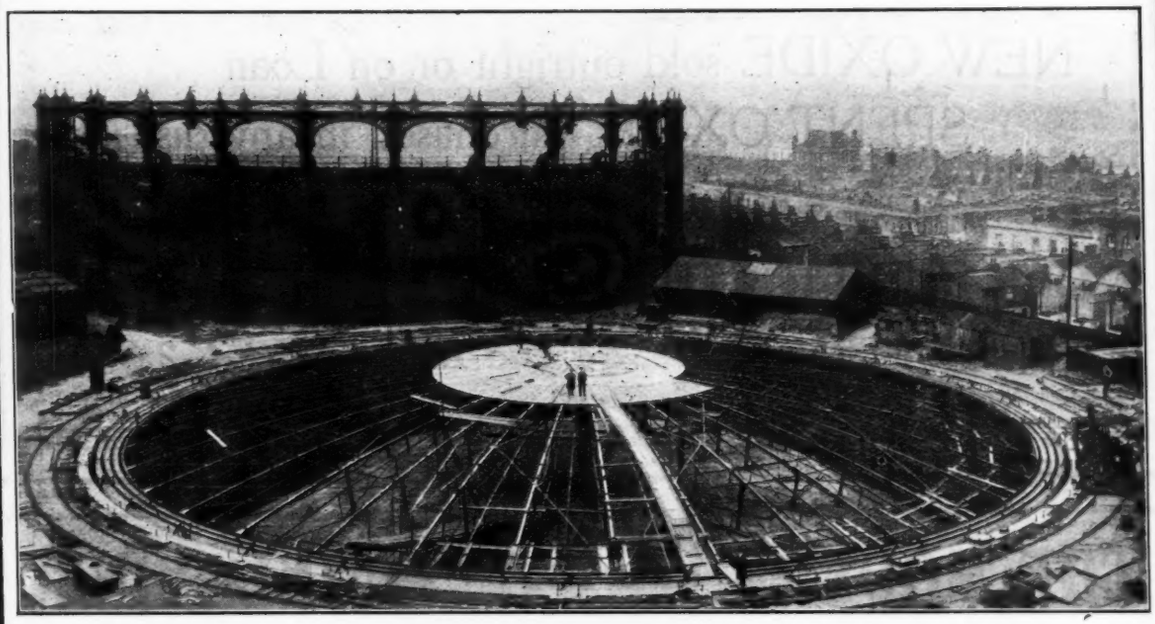
LONDON OFFICE:
34, Victoria St.,
Westminster,
S.W.1.

MANCHESTER

TELEPHONES:
Central 54 & 2296.
London Office:
Victoria 7426.

WE CAN CONVERT YOUR OLD FRAME-GUIDED SINGLE OR TWO-LIFT GASHOLDER INTO A THREE, FOUR, OR FIVE-LIFT SPIRAL,

THEREBY UTILIZING YOUR EXISTING TANK.



PHOTOGRAPH SHOWING THE

4 MILLION SPIRAL HOLDER

NOW BEING ERECTED AT THE FULHAM WORKS OF THE GAS LIGHT & COKE CO. IN THE EXISTING BRICK TANK OF A DISMANTLED

TELESCOPIC GUIDE FRAMED HOLDER.

To the design of THOS. HARDIE, Esq., A.M.I.C.E.

R. & J. DEMPSTER, LTD.

LONDON OFFICE:
34, Victoria St.,
Westminster,
S.W.1.

MANCHESTER

TELEPHONES:
Central 54 & 2298.
London Office:
Victoria 7426.

OXIDE OF IRON

— FOR —

Gas Purification

As supplied by this Company for over 50 Years

NEW OXIDE sold outright or on Loan
SPENT OXIDE purchased in any district

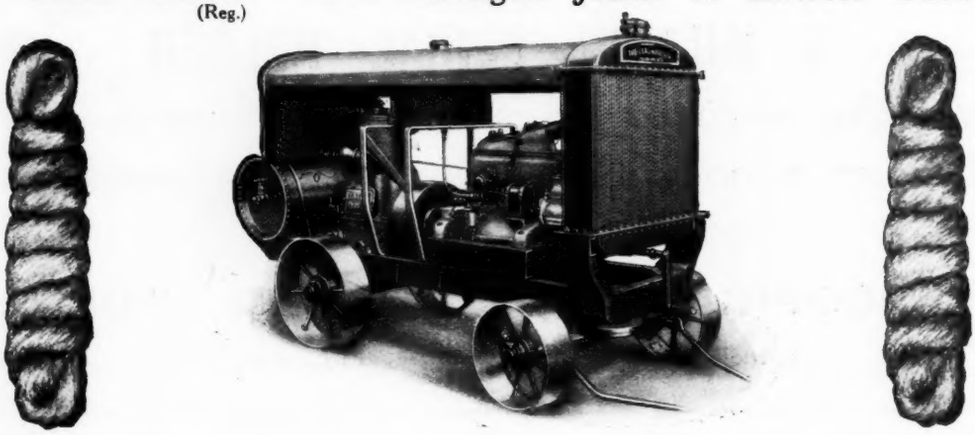
GAS PURIFICATION & CHEMICAL CO. Ltd.

Palmerston House, 34 Old Broad St., E.C.2

Telegrams: "Purification Stock, London" Telephone: London Wall 9144

THE MODERN WAY OF MAINLAYING.

"S.V.20"—The All-round compressor for pipeline work.
"LEAD WOOL" (Reg.)—For Strongest Joints at Lowest Cost.



THE MACHINE breaks up roads, digs trenches, caulks joints, and rams back earth.
THE MATERIAL halves consumption of lead, saves cost of fuel and appliances.
BOTH ensure best possible results—and save money.

The LEAD WOOL CO. Ltd.

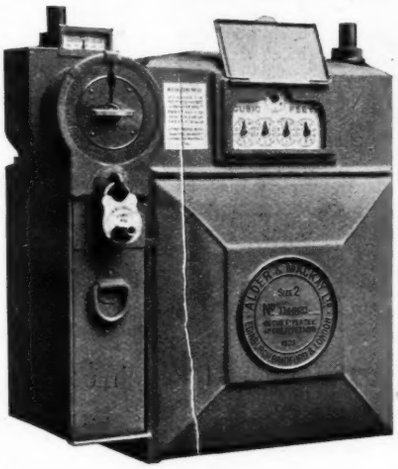
Snodland, Kent.

Telephone: No. 36 Snodland. Telegrams: "Strength, Snodland."

FINEST MATERIALS

EXPERT WORKMANSHIP

FITTED WITH
PATENT VALVE



THE MARK IV. P.P.

Alder & Mackay Ltd
Established 1850

ACCURACY

DURABILITY

WILSON'S "CERTUS"

FULLY PATENTED.

IMPORTANT

No. 1 Nipple greases back stuffing box
No. 2 „ „ front „ „
No. 3 „ „ centre „ „
No. 4 „ oils back leather
No. 5 „ „ front „

GRAND PRIX D'HONNEUR
Diploma and Special Medal
ANTWERP 1926.

The only Meter made to-day which can be truly called a scientific instrument.

Being adopted by some of the largest Undertakings in the Country.

Many thousands supplied.

THE ONLY Meter manufactured which can be re-oiled and re-greased throughout with **PERFECT** ease without breaking seals or removing from consumers' premises.

Operation of a simple **SYSTEM** with few minutes' work.

The only perfect lubricating device **FOR HIGH CAPACITY METERS.**

BY USING THESE METERS YOU WILL STOP

Your large repair bills.
Your unaccounted for.
Your dry rot in leathers and cases.
Your incorrect registration.
Your leaks at index.

It is worth your while to look into these matters.

Further Particulars from :—

GEORGE WILSON GAS METERS LTD., COVENTRY

LONDON WORKS - - 46-47, AUCKLAND ST., LAMBETH, S.E. 11
MANCHESTER WORKS - 268, STOCKPORT ROAD, MANCHESTER

A STRIKING TESTIMONY

TO

"Supastone"

THREE-PLY GLASS

GLASSWARE

Facts Speak for Themselves!

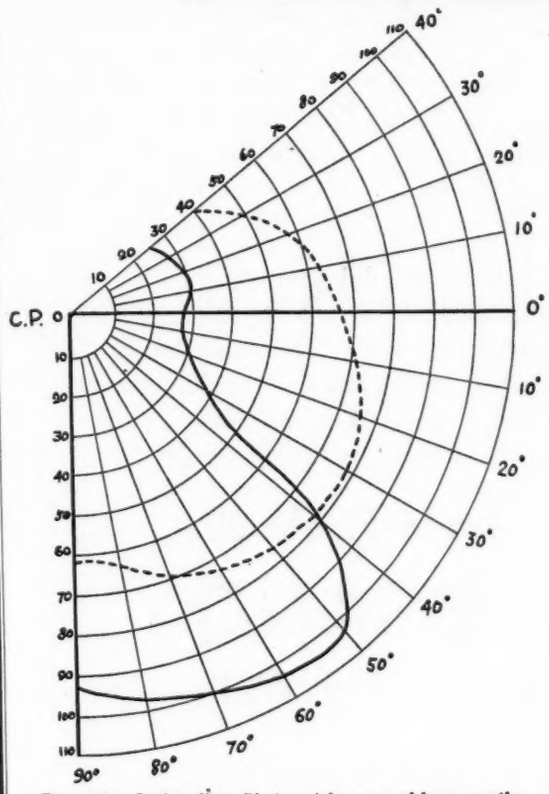


Fig. 143b.—Broken line—Photometric curve of bare mantle. Full line—Photometric curve of mantle and "Supastone" globe.

Extract from the "GAS SALESMAN," Feb. 10, 1926.

"'Supastone' is a comparatively new material, and it has forged very much to the front recently. This excellent and moderate-priced material is made of three-ply glass—inside clear, centre opal, and exterior satin finish. The common form of plain (general purposes) 'Supastone' globe, shown in fig. 143a, intensifies the light at the lower angles—see polar curve, fig. 143b—and gives a mellow, creamy hue to the emerging light, the whole surface of the globe possessing a uniform brightness. 'Supastone' is available in a large variety of plain and decorated forms for globes and bowls, and makes a most satisfactory diffusing material."

Fig. 143a.—Universal "Supastone" globe.

Stocked in SHADES and BOWLS—Plain and Hand-Painted.

LISTS ON REQUEST.

THE WHOLESALE FITTINGS CO., LTD.

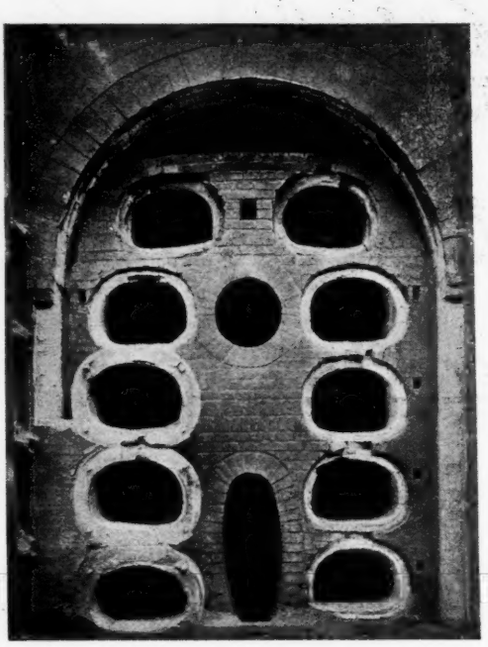
23, 25, & 27, Commercial Street, London, E.1.

78/80, High Street, MANCHESTER.

14, North Street, Stokes Croft, BRISTOL.

Economy in the Retort House

"BLUEBELL" 95% SILICA SEGMENTAL RETORTS



Approx. Analysis.

Silica	96·28%
Alumina	1·38
Titanic oxide	0·08
Ferric oxide	0·29
Lime	1·95
Magnesia	0·07
Alkali	0·08
	100·13%

Melting point Cone 34.
Approx. 1750° C. or 3182° F.
True Specific Gravity 2·33.

Setting of "Bluebell" 95% Silica Segmental Retorts in process of demolition at Beckton Gasworks after over 6 years' work. Combustion Chamber and Cross Walls "Bluebell" Silica material. Setting in excellent condition and could have been worked for a still longer period but taken down to permit of reconstruction of the whole Retort House.

Also Makers of High Grade Firebricks

"THISTLE" BRAND

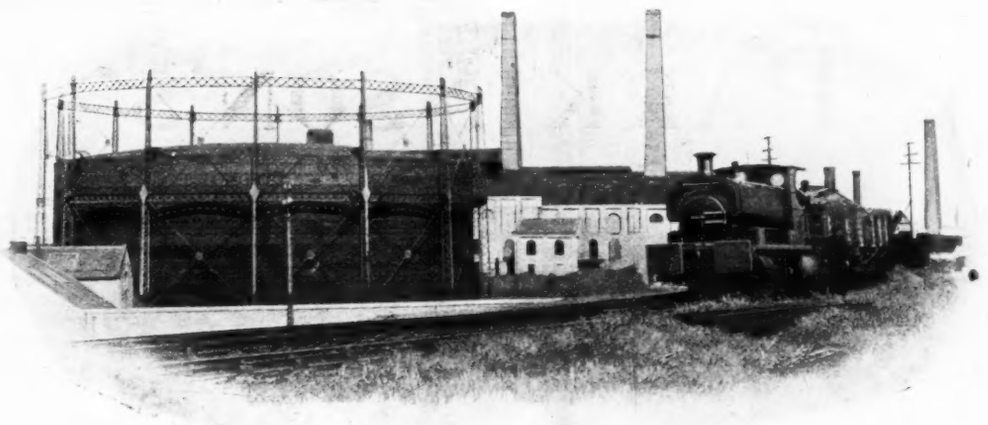
for Producer Arches and Side Walls

BOTH BRANDS EXTENSIVELY USED BY LEADING CONTRACTORS FOR VERTICAL RETORTS

Productive Capacity 1,000,000 Bricks Weekly

JOHN G. STEIN & COMPANY LIMITED

BONNYBRIDGE — SCOTLAND



ANDREW BARCLAY, SONS, & CO., LTD.,

CALEDONIA WORKS, KILMARNOCK.

All Sizes and Types of LOCOMOTIVES for Gas Works, any Gauge.

WORKS ALREADY SUPPLIED:

BIRMINGHAM, EDINBURGH, GLASGOW, MANCHESTER,
LONDON GAS LIGHT & COKE CO., AND MANY OTHERS.

FIRELESS LOCOMOTIVES TURN WASTE HEAT TO USEFUL SERVICE.

ASK FOR PARTICULARS.

THE DAVIS

"Balance" (Steamless) Radiator

Ideal for GARAGE HEATING

The "Balance" Radiator provides a safe, hygienic, and highly economical means of warming any room where a hole can be made in the wall to take the Flue-and-Air-Box. From this ingenious *balanced* contrivance the Radiator takes its name. The Flue-and-Air-Box discharges the products of combustion outside the room; from outside the room also it takes the air for the burning of the gas. It also ensures proper combustion of the gas, however strong a wind may be blowing outside.

Send for Illustrated Price Lists.

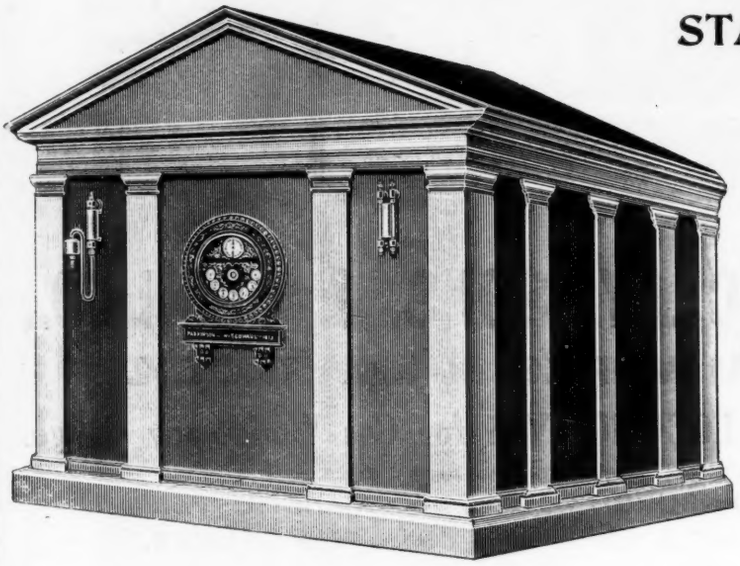
THE DAVIS GAS STOVE CO., Ltd.,

60, OXFORD STREET, LONDON, W.1. **Works: LUTON**

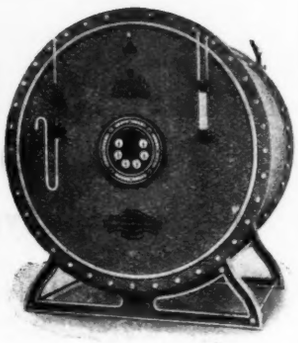
(Radiation Ltd., Proprietors.)

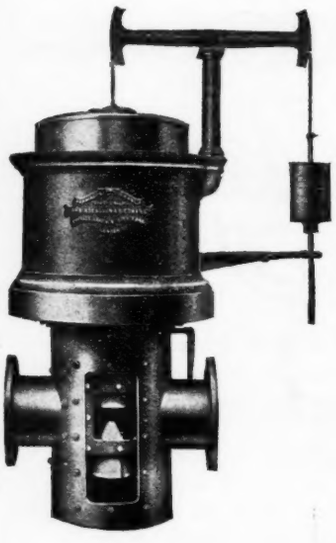
PARKINSON'S

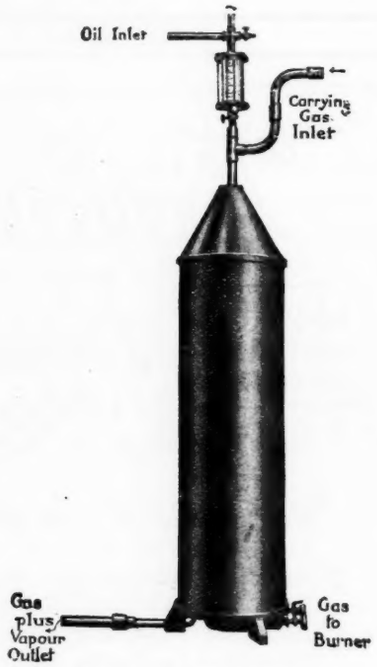
STATION METERS



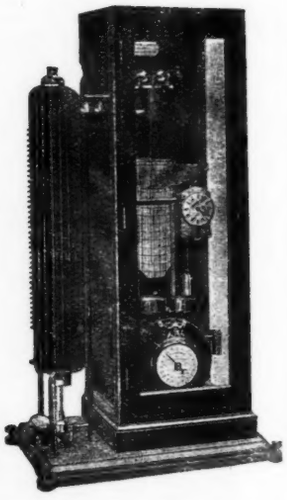
All sizes up to 300,000 c.ft. per hour.







Petroleum Vaporiser.



Station Governors.

All Sizes.

And for all conditions.

W. PARKINSON & CO.,

INCORPORATED IN PARKINSON & COWAN (GAS METERS), LTD.

COTTAGE LANE CITY ROAD, LONDON, E.C.1.	BELL BARN ROAD, BIRMINGHAM.	MORNINGTON STREET, ORMEAU ROAD, BELFAST.
Telegrams: "INDEX, ISLING, LONDON."	"GASMETERS, B'HAM."	"PREPAYMENT, BELFAST."
'Phone Nos.: 4270 Clerkenwell	2245 Midland, B'ham.	3374 Belfast.

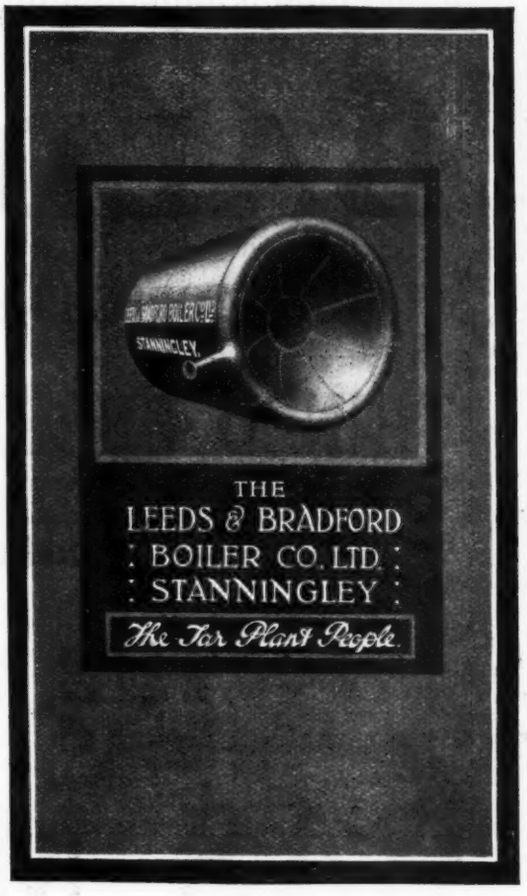
Recording Gas Calorimeters. "Gross" or "Nett."

HOUSING

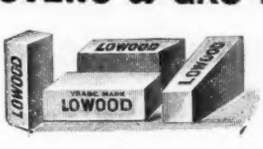
The "All-Cast" Wash-Boiler (Gas-heated) is specially manufactured to the requirements of the D.B.M.S. by ARDEN HILL & CO.

The outer case is of cast iron and the pan also is of cast iron, specially treated as protection against rust. This boiler has a wooden lid, completely removable, which is also useful for carrying hot clothes. Arden Hill's "All-Cast" is the ideal gas-heated wash-boiler for Housing Schemes, very simply fitted, and exceptionally economical on gas.

ARDEN HILL
and Company,
Acme Wks., Aston, Birmingham,
and
19 Queen Victoria St., London, E.C.4
(Radiation Ltd., Proprietors.)



J. GRAYSON LOWOOD
& CO, LTD.,
DEEPCAR, nr. SHEFFIELD
MANUFACTURERS OF HIGH-CLASS
SILICA BRICKS
for use ESPECIALLY in
COKE OVENS & GAS-WORKS



Fire Bricks, Fire Clay, Cupola Blocks, Runners, Sleeves, Stoppers, Nozzles, &c.
GROUND GANISTER,
STEEL MOULDERS' COMPOSITION,
Silica Cement and Paint.
MAGNESITE BRICKS AND CEMENT.

WORKS:
DEEPCAR, SHEFFIELD, MIDDLESBRO' & CASTLETON
Telegrams: "Lowood, Deepcar." **(YORKSHIRE)** Nat. Telephone—No. 18, Stocksbridge, Sheffield.

BALDWINS'

STAFFORDSHIRE BEST CHARCOAL

TINNED SHEETS & TINPLATES

Heavily Coated with Pure Tin

THE material for GAS METERS.

ALL STAFFORDSHIRE PLATES are Tinned by a special process, peculiar to BALDWINS, Ltd., which ensures a solid thoroughly even coating, and a real amalgamation between the Steel and the Tin.

Makers of the famous

COOKLEY K

HIGH CLASS HEAVILY COATED TINNED SHEETS.

Known throughout the World as the finest Tinned Sheet produced.

BALDWINS LTD.

(Midland Branch), Wilden Ironworks, nr. Stourport, Worcs., England.

London Offices: 67-71, QUEEN VICTORIA STREET, E.C. 4.

THE
VITREOSIL
TEST
Cold water poured on red hot Vitreosil Gas Globe does not crack or harm it in the slightest. No other globes would survive this.

Which globes?

When specifying globes for a gas-lighting scheme consider the advantages offered by Vitreosil (pure fused silica).

Vitreosil Globes are thoroughly efficient; they convert all glare into a flood of soft, restful light. Firms who have kept records have found them the most economical proposition, since their perfect resistance to heat and variations of temperature makes them practically everlasting in use.

They save the pocket!

VITREOSIL

HEAT-PROOF

Gas Globes

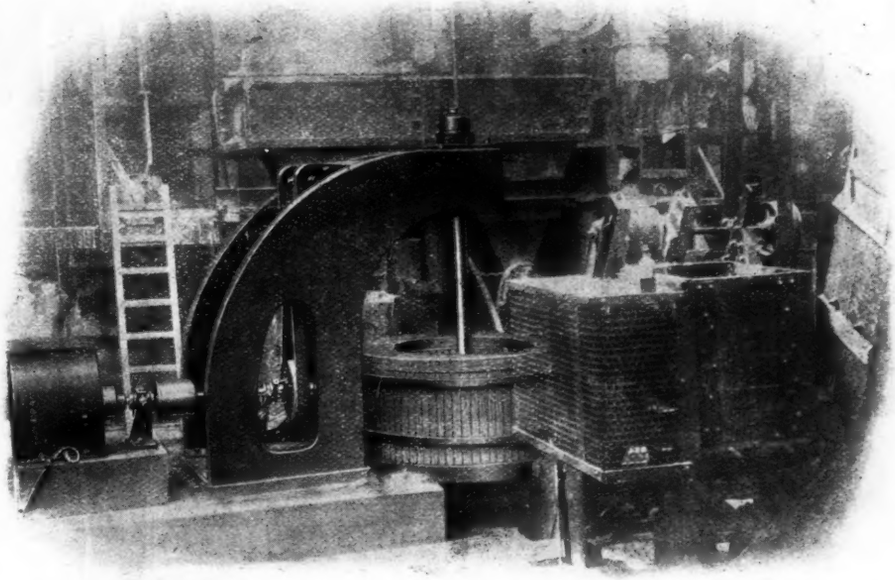
Write for Trade Price List.

THE THERMAL SYNDICATE, LTD.,
Vitreosil Works, Wallsend-on-Tyne.
(Est. 20 years.)
London Dept.:—28, Victoria Street, S.W. 1.
Sole Agents in Australia: Waring, Martin & Harris, 49, Clarence St., Sydney.

"Broadbent"

CENTRIFUGALS

FOR DURABILITY



42 in. Swan-neck Type Machine driven by separate motor. (Steel Outer Case lagged with wood.)

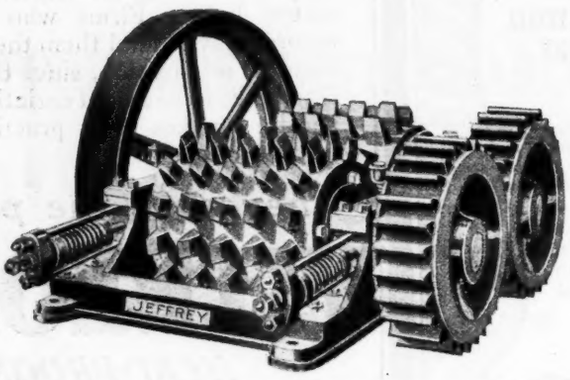
DRIVEN BY STEAM, BELT, or ELECTRICITY.

The World's Best Machines for Drying Sulphate of Ammonia.

Thomas Broadbent & Sons, Ltd.
HUDDERSFIELD

BASKETS made in BLACK STEEL, COPPER, or MONEL METAL.

JEFFREY
COKE SIZERS.



SPECIALLY DESIGNED ROLLS WITH RENEWABLE TOOTHED SEGMENTS REDUCE COKE ECONOMICALLY TO A UNIFORM PRODUCT.

ALSO: COKE SCREENS, CONVEYORS, ELEVATORS, ETC.

HUGH WOOD & COMPANY, LTD.

TELEPHONE: ROYAL 0430. 65, FENCHURCH STREET, LONDON, E.C.3. TELEGRAMS: "HUWOD, FEN, LONDON."

Head Office: NEWCASTLE-ON-TYNE. And at NOTTINGHAM & PRESCOT.

WRITE

W. SPENCER & SONS,

SOUTHALL, MIDDX.

FOR

PURIFIER GRIDS

ALSO ASK FOR PARTICULARS OF OUR LATEST PATENT GRIDS.

WILTONS NEUTRAL SULPHATE DRIER.

CLAIMS.

(1). The salt cannot be discharged before being thoroughly dried.

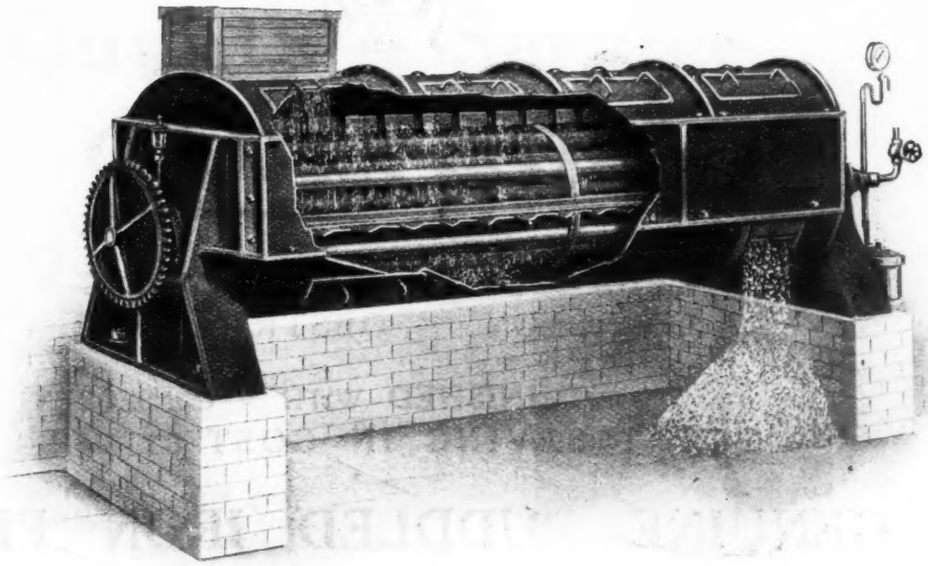
(2). No grinding of crystal owing to slow speed.

(3). The only drier capable of dealing with 3 to 5 tons straight from the draining table.

(4). Cast iron construction and low maintenance costs.

(5). Heat applied in the centre. All heat radiation going through salt.

(6). Nearly 100 machines in operation.



The Chemical Engineering & Wiltons Patent Furnace Co., Ltd.

Telegrams: "EVAPORATOR, PHONE, LONDON."

76, Victoria Street, S.W.

Telephone: VICTORIA 2417.

SILICA RETORTS.

MINIMUM EXPANSION
The Oughtibridge Silica Firebrick Co., Ltd.
Oughtibridge, Near Sheffield.
Estd 1858.

"S.P. Silica" 95% Retorts

"Silco" Retorts 90% Silica.

Highest Grade Silica Bricks & Blocks for Gas Works.

Plastic Silica Cement

"Silco" Cement & Ground Ganister

SILCO RETORTS.

any Section or any Type of Joint supplied as required.

MITRE BRAND

1820

Bagnalls

LEAKAGES BAD THREADING
CORROSION OBSTRUCTION

MAY BE **DIMINISHED** WITH A CONSEQUENT
GREAT SAVING IN COST BY USING

GENUINE PUDDLED IRON PIPES

MITRE BRAND IS GUARANTEED

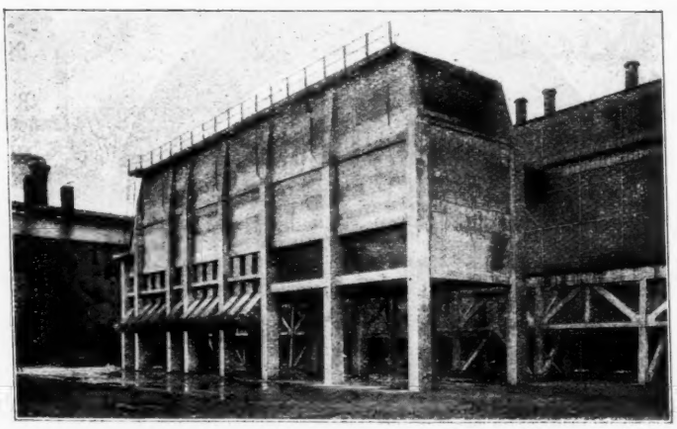
JOHN BAGNALL & SONS LTD., WEDNESBURY, S. STAFFS.

SIMPLEX CONCRETE PILES, LIMITED

CONTRACTORS FOR REINFORCED CONCRETE STRUCTURES FOR GAS-WORKS.

All Classes of Piling & Foundation Work Undertaken.

Reinforced Concrete Rafts—
For Chimneys
Retort Houses
Gasholders, etc.



Reinforced Concrete
Hoppers
Crane Gantries
Breaker Pits
Coal Stores
Coke Stores
Water Towers
Pump Houses
Tar & Liquor Tanks
Etc.

Write for Illustrated Booklet :

137, VICTORIA STREET, WESTMINSTER, S.W. 1

31, BOLD STREET, WARRINGTON **10, COOK STREET, GLASGOW**

Quality & Service

Quality

The premier quality of the Thomas Glover Meter is known and appreciated the world over.

More than two millions of these meters have been supplied to Gas Undertakings. Wherever they are installed satisfaction, both to Undertaking and Consumer, is assured.

Service

The Thomas Glover Lorry Service covers the realm.

Gas Undertakings using it are saved all trouble and expense connected with carriage and packing, besides being assured of their meters arriving in good condition.

ORIGINAL DRY METER MAKERS
ESTABLISHED IN 1844

THOMAS GLOVER
& CO., LTD.
Gothic Works, Angel Rd., Edmonton
N. 18

Branches at: BELFAST, BIRMINGHAM, BRISTOL, EDINBURGH, GLASGOW, MANCHESTER & NEWCASTLE-ON-TYNE

Introducing BOB CORT and his Bag of Tricks

London Bridge is falling down—

That's how it started—

Then the Middlesex Hospital took up the song.

And now the London County Council have started a new nursery rhyme—It goes. Waterloo Bridge is falling down—falling down—falling down.

Londoners can find the tune in the rate book.

It's a pity they could not have left the gallant old bridge alone—It was becoming one of the finest switchbacks since the Wembley Exhibition—

One of their most brilliant engineers, however, discovered it was subsiding – It is rumoured that he fell into a dent one evening on his way to see Hamlet at the Old Vic He didn't look ahead—neither did the L.C.C.

Now they are all looking down their noses.

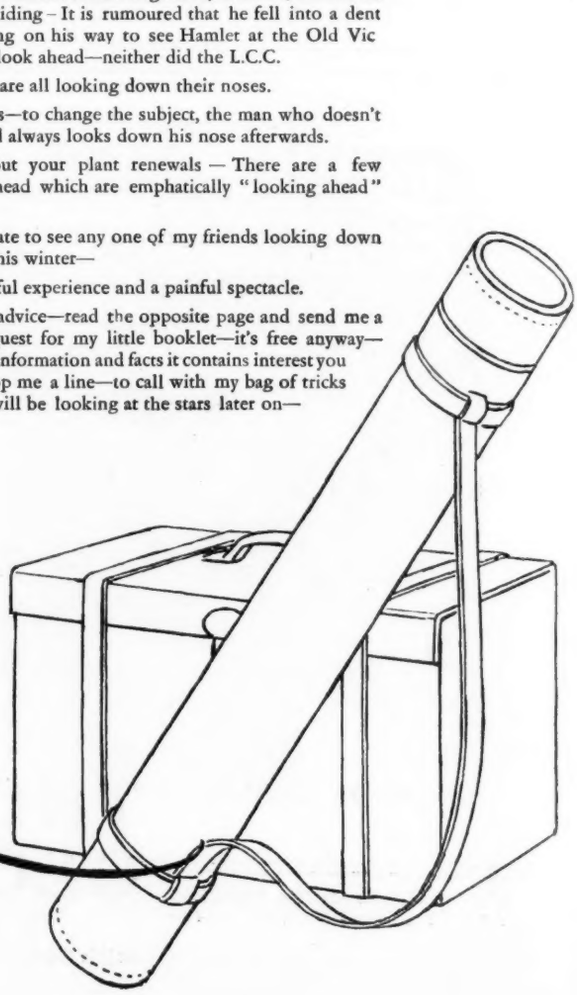
In business—to change the subject, the man who doesn't look ahead always looks down his nose afterwards.

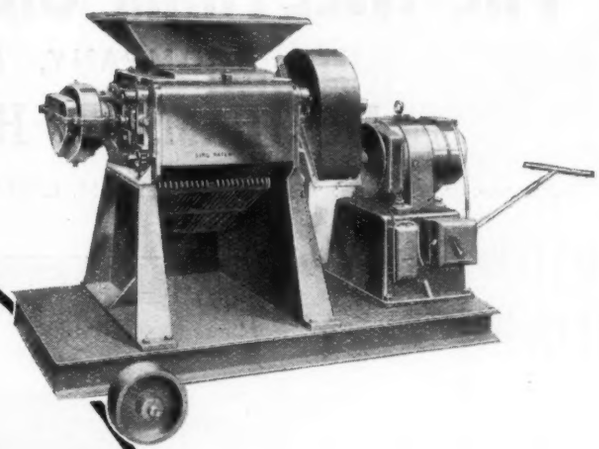
What about your plant renewals — There are a few months ahead which are emphatically "looking ahead" months—

I would hate to see any one of my friends looking down his nose this winter—

It's a painful experience and a painful spectacle.

Take my advice—read the opposite page and send me a postal request for my little booklet—it's free anyway—and if the information and facts it contains interest you —just drop me a line—to call with my bag of tricks and you will be looking at the stars later on—





Corts Coke Cutting Machine (Sims' patent). A machine capable of reducing gas or oven coke evenly graded to any desired size, with a minimum of waste.

A machine built by Engineers for Engineers—in which every possible provision has been taken to counter the unequalled abrasive action of coke.

Fitted with finest manganese steel cutters or rolls.

Also fitted with a safety spring release and shearing pin driving coupling, to eliminate breakdowns.

An adjusting device is provided to take up the wear on the cutters and to regulate the size of the cut coke. All gears are machine cut, and enclosed in dust-proof oil bath.

All bearings are ring oiling and dust-proof.

Robt. CORT & SON,
LIMITED,
Engineers and Ironfounders,
READING.

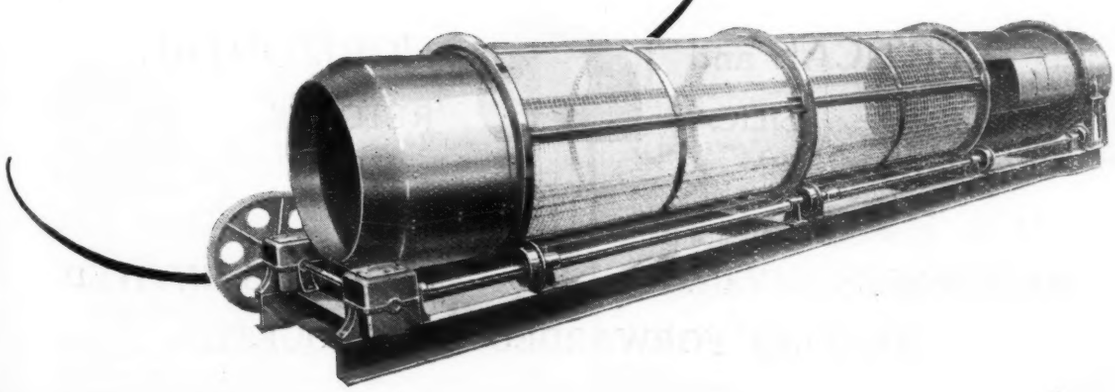
CORTS IMPROVED ROTARY TYPE SCREEN.
(Patent applied for.)

Incorporating the following improvements:—

Friction driven, on both sides and at different points throughout the length, thus eliminating the use of exposed gearing central shafts—and "spiders," leaving a free bore for easy travel of coke.

Gearing employed is machine cut and enclosed in dust-tight oil bath cases.

The main structure of the screen is fitted with renewable wearing portions.



THE MELTHAM SILICA FIRE BRICK

COMPANY, LIMITED,

MELTHAM, near HUDDERSFIELD.

TELEGRAPHIC ADDRESS; "REFRACTORY," MELTHAM. TELEPHONE: 21 MELTHAM.

Minimum of Expansion Guaranteed

Satisfactory Results Assured.

STAND AT THE NATIONAL GAS EXHIBITION, BIRMINGHAM.

MANUFACTURERS OF HIGH-CLASS

SILICA BRICKS AND BLOCKS

for GAS WORKS and COKE OVEN PLANTS

To any Design. ***As Supplied to some of the Largest Works in the Country.***

VERTICAL and SILICA HORIZONTAL RETORTS

A SPECIALITY.

REFERENCES GIVEN. ENQUIRIES INVITED.

SAMPLES FORWARDED ON REQUEST.

Bourne's Naphthalene Solvent.

"GAZINE"

(Registered in England and Abroad)

A Radical Solvent and Preventative of Naphthalene Deposits, and for the Automatic Cleaning of Mains and Services. It is used also for Enriching and Odorizing Water Gas.

Used successfully for 20 years by many Gas Companies.

Also BOURNE'S ANTI-CORROSIVE OIL for Lubricating Gas Mains and Meters.

SUPPLIED ONLY BY

C. BOURNE

West Moor Chemical Works,

KILLINGWORTH

OR THROUGH HIS AGENTS

F. J. NICOL & CO., LTD.,

Pilgrim House, Newcastle-on-Tyne.

Telegrams: { "DORIC, NEWCASTLE-ON-TYNE." / "BOURNE, FOREST HALL." — National Telephone 2497.

THE ORIGINAL SWISS FITTING

You can avoid leaky pipework by using **+GF+** Malleable Tube Fittings. These have clean, accurate threads, and screw on easily, making perfectly tight joints. They never split, owing to the strengthening bead, and the exceptional quality of the British iron of which they are made.

All **+GF+** Malleable Fittings are tested to 300 lbs. per sq. in. Write for list.

EVERY FITTING +GF+ GUARANTEED. Malleable Tube Fittings

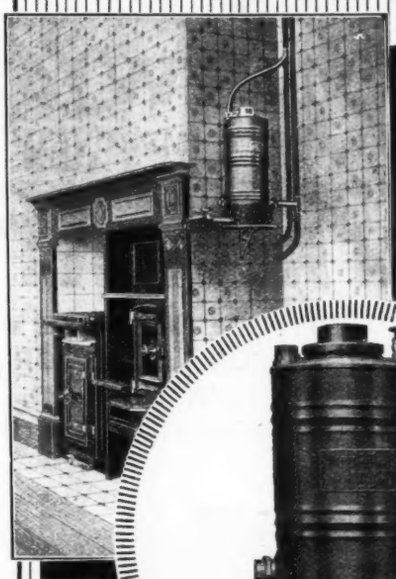
Immediate deliveries, all sizes $\frac{1}{8}$"—6". 8,500 types.

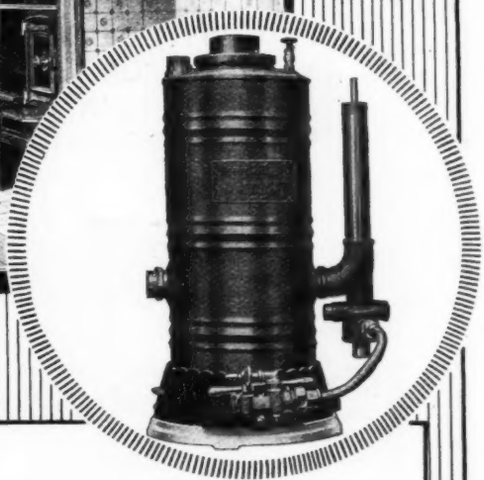
LE BAS TUBE CO., LTD.,

Dock House, Billiter Street, London, E.C. 3.

E.I.H.

The WILSON 'CIRCULATOR' WATER HEATER





Many thousands of these circulators have been supplied and are giving every satisfaction.

Copper construction ensures particular suitability for soft water districts. The gas burners are exceptionally efficient and very economical in working. Full particulars, sizes and prices, etc., gladly sent on application.

Manufactured by

WILSONS AND MATHIESONS, LTD

Carlton Works, Armley, Leeds.

Radiation Ltd. Proprietors.

GEORGE ORME & CO.

(Branch of Meters, Limited),

Atlas Meter Works,

Telegraphic Address: "ORME, OLDHAM."
Telephone No.: 93 OLDHAM.

PARK STREET, **OLDHAM.**

"NEW CENTURY"

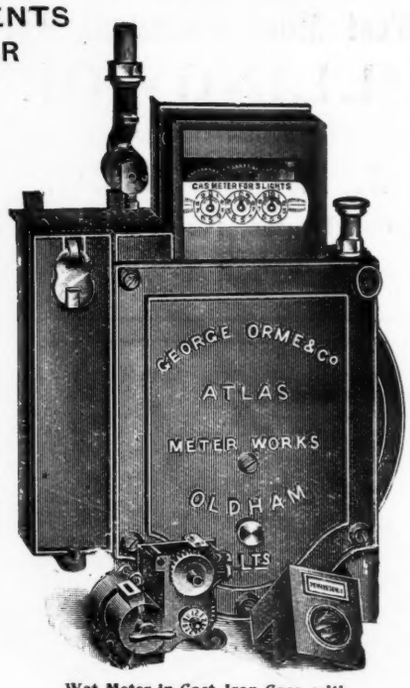
IMPROVED PATENT COIN

PREPAYMENT GAS METERS

FITTED WITH DETACHABLE ATTACHMENTS
ARRANGED FOR **1d., 1s.,** OR ANY OTHER
COIN DESIRED.
SATISFACTION ASSURED.

Dry Meter in Tin-Plate Case, fitted with Attachment.

These Meters can now be supplied either with Price Change Wheel or Change-Plate Arrangement.



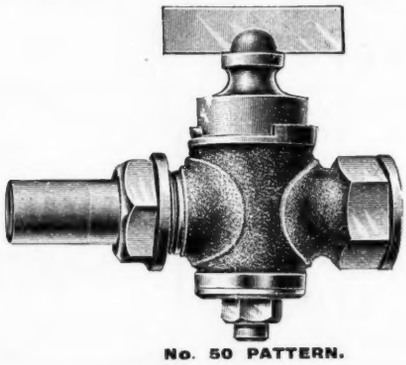
Wet Meter in Cast-Iron Case, with Attachment Removed.

STRONG MAIN GAS COCKS, FERRULES, &c.

— ALSO —

STEAM AND WATER FITTINGS

OF THE VERY BEST QUALITY AND WORKMANSHIP.



No. 50 PATTERN.

WE SOLICIT THE FAVOUR OF YOUR ENQUIRIES.

EFFICIENT STEAM PLANT

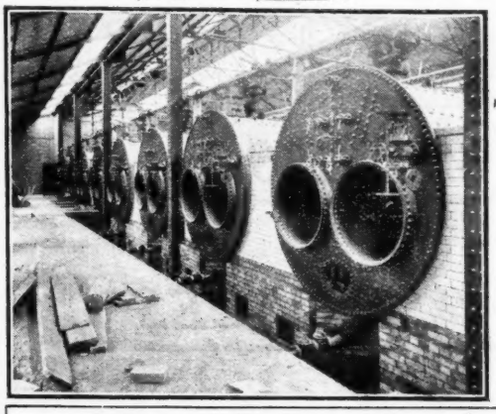
Telegrams:
"Danks, Netherton, Worc."

PLEASE NOTE
DANKS.
NETHERTON

Telephone:
Cradley 25

BOILERMAKERS
ENGINEERS
BUILDERS

Boilers, Receivers, Tanks, Washer-Tubes, Sizing Screens, Platework, Boiler & Economiser Settings, Chimneys: Brick & Steel.



H.C. VAUX

H. & T. DANKS (NETHERTON) LTD., NETHERTON, DUDLEY.

FOR GAS WORKS.

EMPLOY OUR "SERVICES"

AND FIT

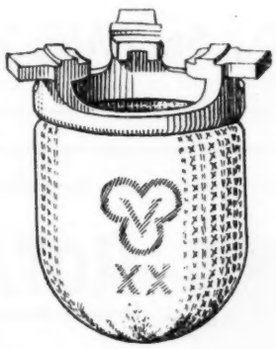
OUR METERS

TO YOUR "SERVICES"

Better Lighting and Cooking Apparatus

VERITAS Street Lighting Burners. These have recently been re-designed, embodying several improvements in construction and bringing them to a high standard of perfection. This, coupled with their comparatively low cost, makes them indispensable for efficient and economical Street Lighting.

VERITAS Mantles. Used in conjunction with the above Burner will bring your Street Lighting to the highest degree of excellence and efficiency.



THE BAKERLOO Gas Cooker is of up-to-date construction, modern design, and pleasing in appearance. It is beautifully finished, all parts being ground and polished.

Fitted with white enamelled tiled panelled sides and doors.

Write for Current Illustrated Price List.

Falk, Stadelmann, & Co. LTD.

VERITAS LIGHT WORKS

Head Office: 83-93, FARRINGDON ROAD, LONDON, E.C.1.

BRANCHES:—

GLASGOW: 72-8, Great Clyde St.
MANCHESTER: Rochdale Road.
BIRMINGHAM: 81-4, Lionel St.
NEWCASTLE-ON-TYNE: 1, Hanover Square.
DUBLIN: 29, Exchequer St.

Standard Patching Cements

BY APPOINTMENT

FOR nearly half a century we have been manufacturing Fire Cements—PURIMACHOS, the Original Plastic—and more recently, in response to many enquiries, DRYKOS, the perfected Fire Cement in powder form. These Cements are unsurpassed for setting and repairing Retorts, washing the insides of Retorts in and out of action to form a Glaze, and for all other purposes where strong, gas-tight joints are essential.

¶ DRYKOS is manufactured in several grades; our Standard Grade is recommended for Fireclay Retorts, and our H3 Grade is specially manufactured for use in connection with Silica Retorts and Bricks.

¶ A free working sample of either Cement will be forwarded on application.

Purimachos Plastic Fire Cement (Regd.)

Drykos Dry Fire Cement (Regd.)

PURIMACHOS, LTD., *St. Philip's*, BRISTOL

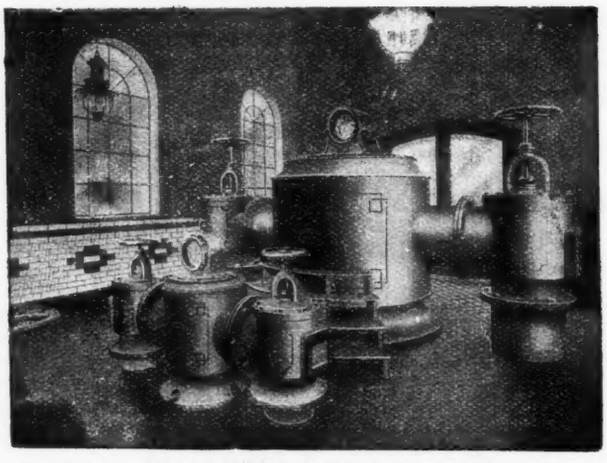


Illustration showing Station Meter House with two Type A Rotary Meters and Valves.

THIS INSTALLATION, measuring the entire make of purified coal gas, was only ordered after a prolonged test of a Rotary Meter run tandem with a Station Meter of the ordinary Wet Drum Type.

ROTARY METERS

RANK SECOND ONLY TO THE POSITIVE WET DRUM TYPE of STATION METER and are GREATLY SUPERIOR to any INFERENTIAL METER.

STANDARD TYPE FOR CLEAN PURIFIED COAL or WATER GAS.

SPECIAL DESIGN FOR UNPURIFIED GASES.

INEXPENSIVE
ACCURATE
RELIABLE

SEND US A NOTE OF YOUR REQUIREMENTS AND WE SHALL KNOW WHAT TO SUGGEST.

THE ROTARY METER COMPANY, LTD.

Talbot Road, Stretford, Manchester.

NEWBRIDGE

Automatic Gas Controllers.

EVERYWHERE you will find "Newbridge" controllers being used on account of their simplicity and reliability. All adjustments to a "Newbridge" controller can be made at the lamp-head *with one hand*. The dial does not revolve when winding; each tappet moves easily and independently; there is no backlash in the dial. These are vital points worth considering. All "Newbridge" controllers are quick lighters—"a feature conducive to cleanliness and economy." In addition, "Newbridge" controllers—including the movement—are British-made at our works in Bath. An installation will cut your public lighting costs and at the same time add to the efficiency of the service.

Recent large orders for our controllers, TYPE 3A/UNI, include:—

NEWCASTLE-ON-TYNE ... ... 2,300 (repeat order). READING ... 2,450 (complete installation).
SOUTH METROPOLITAN GAS CO. ... 2,000 ditto. LINCOLN ... 500 (repeat order).
Other repeat orders from:—BIRMINGHAM, ROTHERHAM, BLACKPOOL, SHEFFIELD, DERBY, HULL, etc., etc.

The most popular model for unit lamp control

TYPE 3A/UNI.

15-day run.

Front view.

Movement detached from gas cock.

WE call special attention to this model, which in view of its many advantageous features, outstanding performance, and reasonable price has proved to be the biggest seller of our whole range. The clockwork movement is instantly detachable from the gas cock without disturbing burner, by-pass, or mantle. The movement is enclosed in a rust-proofed steel case—unbreakable and non-corrosive—whilst a lubricator is fitted to the gas cock, rendering it unnecessary ever to remove the plug for cleaning or oiling. Unfailing service year in and year out at minimum maintenance costs is rendered by this controller—in short, it is the finest controller on the market for general use.

Newbridge Suspension Lamp Controllers. TYPE 14/3.

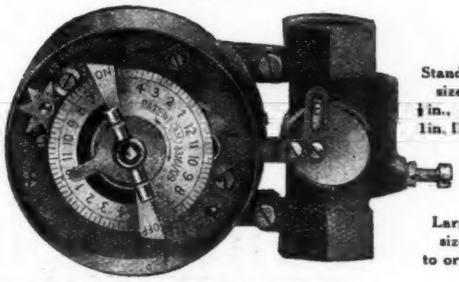
8 or 16-day run.

A POPULAR and thoroughly reliable controller. Clockwork movement is instantly detachable and enclosed in weatherproof case. For fitment to various types of suspension lamps. Can be arranged for midnight reduction, or twice lighting and extinguishing every 24 hours, when desired.

Newbridge Main Tap Controllers. TYPE 5/3/Selective.

8-day run.

Solar compensating dial to order.



Standard sizes: ¾in., 1in., 1in. IRON

Larger sizes to order.

A DEVELOPMENT of our well-known TYPE 5/3 for operation of large gas ways, and ideal for control of groups of lamps, shop window lights, signs, flat lighting, clock dials, gas engines, advance heating of water, linotype metal, lead, radiators, etc., this model is fitted with selective device which renders controller inoperative on days specified by the user.

Send for our complete Catalogue "G.2." and samples for free test.

Sole Makers:— **THE HORSTMANN GEAR COMPANY, LTD.,**
NEWBRIDGE WORKS—BATH.

Grams:—"Horstmann, Bath." Phone:—Weston, Bath, 19.

DEGREES
in the tube trade:

POSITIVE - - - Tubes.

COMPARATIVE - Wrought Iron Tubes.

* **SUPERLATIVE** - S.T.C. Genuine Puddled Wrought Iron Tubes.

* **ONLY MAKERS** - - -

The **Scottish Tube**
COMPANY, LIMITED
34 ROBERTSON STREET, GLASGOW.
S T C

The Pre-payment Price-changer

This attachment (which is shown being fitted to a "Ranelagh" Meter at our Chelsea Works) is a slot mechanism of the highest efficiency and reliability. It is one of the chief reasons for the ever-increasing sales of the

"Ranelagh"
GAS METER

There are no change wheels and there are no loose screws or parts to become detached. Alterations in the price of gas are effected (from the front of the Meter) in a few seconds. The disc has a wide range, varying from 5 to 47 feet in the penny Meter, or 60 to 564 in the shilling type.

Pioneers in the manufacture of Slot Meters having the whole of the attachment accessible from the front.

Fixing the price-changer

GEORGE GLOVER & CO., Ltd.
Dry Meter Manufacturers and Repairers,
RANELAGH WORKS, Chelsea, London, S.W. 3
Branches: Ranelagh Meter Works, East Park View, LEEDS.
City Meter Works, Port Street, MANCHESTER.

MODERN STREET LIGHTING.

The "Falcon" 2-Light Superheater Inverted Lamp Fig. 115 with No. 2 size mantles, and with Fig. 125 Swan Neck Adapter for column, as shown, costs but **37s.** complete, ready for fixing. The lamp has copper case and is very durable. Outside regulation of gas and air.

Can be supplied in 1, 2, 3, and 4 light sizes, and with top cross lever cock if preferred, or with clockwork controller.

Low Maintenance Cost.

High Efficiency.

Many Thousands in Use.

Sole Manufacturers:

HUTCHINSON BROTHERS, LTD.,

Falcon Works, BARNSLEY.

Telephone :
128 & 129 Brierley Hill.

Telegrams :
"Mobberley Perry Holly Hall."

MOBBERLEY & PERRY
LTD.
STOURBRIDGE

For more than half a century we have been manufacturing refractory materials and have been compelled to enlarge our various works each year in order to cope with the increasing demand for our products and we are pleased to inform our very many clients that we are transacting more business to-day than we have ever done before.

Specify

MOBBERLEY & PERRY, Ltd.
SPECIAL B. B. QUALITY
GAS RETORTS.

FLACK.

AMERICAN GAS COALS

D. L. FLACK & SON, LTD.

COAL EXPORTERS

Established 1870

LONDON :: NEW YORK

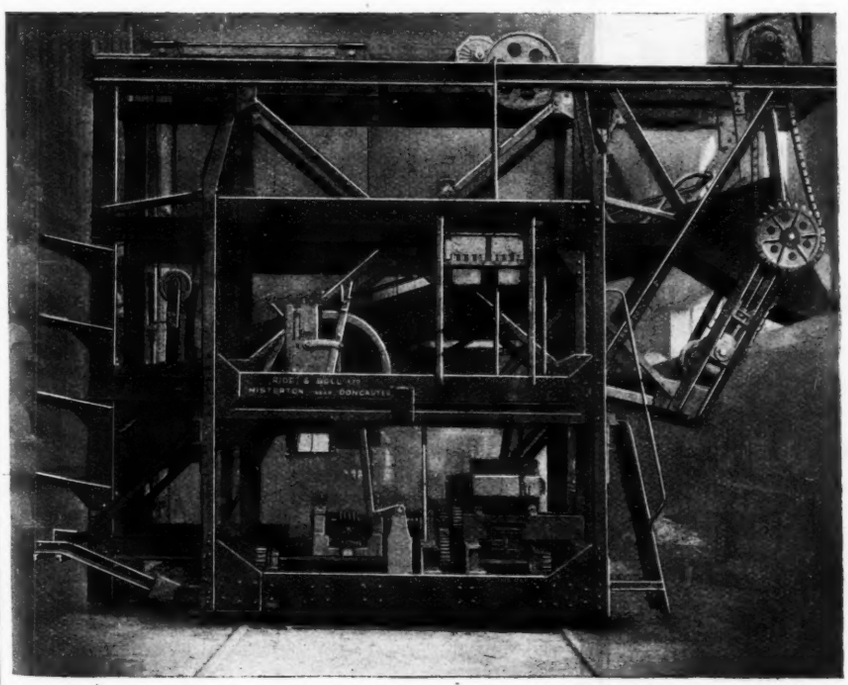
96 GRESHAM HOUSE,
BISHOPSGATE,
LONDON, E.C. 2

Telegrams : Civism, Stock, London
Telephone : London Wall 7553 (Four Lines)

THE SUCCESS OF THE YEAR

THE R. & B. HOT COKE HANDLING MACHINE

(PATENTED)



INSTALLED AT DEWSBURY GAS WORKS.
Gas Engineer and Manager, Mr. HENRY L. BATEMAN.

FEATURES:

NO BREAKING OF COKE.

SPEEDY WORKING.

ABSOLUTE SIMPLICITY.

PARTLY QUENCHES COKE ON ROUTE TO STORAGE BENCH.

DEPOSITS AT ANY POINT ALONG QUENCHING BENCH.

ALL MOVING PARTS ARE STATIONARY UNTIL COKE IS PUSHED.

LOW IN MAINTENANCE.

ETC., ETC.

RIDE & BELL, LIMITED,
MISTERTON,
DONCASTER.

'Phone: 11, MISTERTON.
'Grams: "RIDBEL, MISTERTON, NOTTS."

A "NO-TROUBLE" BURNER

The Bray No. 790D with a new device—the patented diffuser—removes all trouble from gas lighting.

NO POTS TO BREAK. NO LIGHTING BACK.
NO GAUZE TO CHOKE UP.
KEEPS CLEAN. BURNS QUIETLY.

THE **BRAY 790D BURNER**
BRITISH MADE

Please apply for complete lists to **DEPT. E, GEO. BRAY & CO., LTD., LEEDS**

HARDMAN & HOLDEN Ltd.

'Phone: City 8666 / 'Grams: Benzole } Manchester. Works { MILES PLATTING / CLAYTON.

MILES PLATTING, MANCHESTER

SULPHURIC ACID
ALL COAL TAR PRODUCTS

Solvent Naphtha
Heavy Naphtha
Pyridine
Cresylic Acid (Water White)
High Boiling Tar Acids
Carbon Bi-Sulphide
Carbazole
Anthracene
Acenaphthene
Wood Preservatives
Disinfectant Fluids
Insecticides
Ammonium Sulphate (Neutral Grade)

REFINED TAR FOR ROADS
TO ROAD BOARD SPECIFICATIONS

MANCHESTER OXIDE Co. Ltd.

'Phone: Central 5883 / 'Grams: Oxide } Manchester.

MILES PLATTING, MANCHESTER

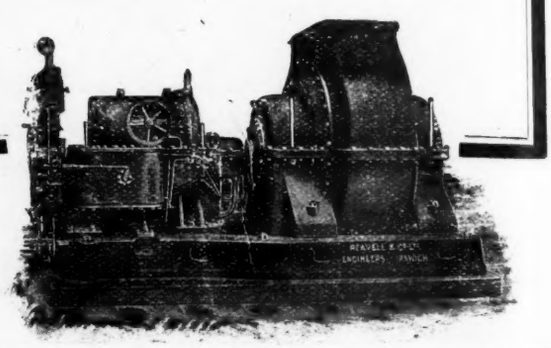
MANUFACTURERS OF
OXIDE OF IRON
For Direct Use in Gas Purification
Prussiates Sulphocyanides
Recovered Sulphur
Buyers of **SPENT OXIDE**

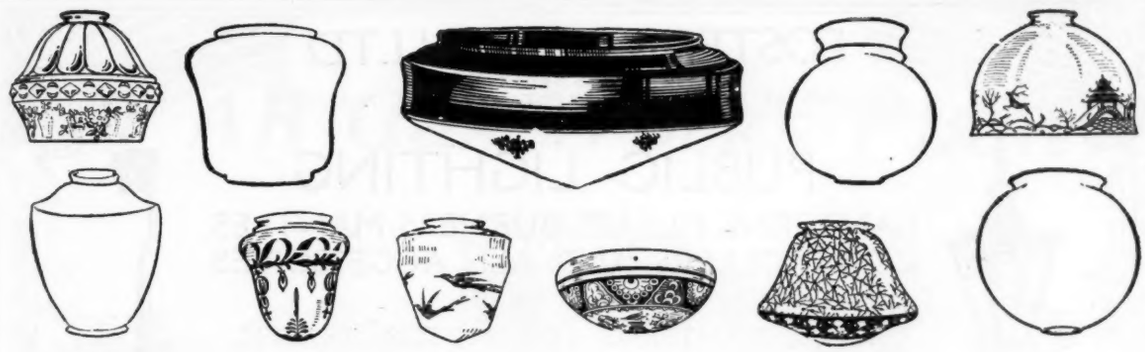
GAS and AIR COMPRESSORS & EXHAUSTERS

We supply a complete range of Compressors & Exhausters for gas and air, suitable for all purposes connected with the Gas Industry, including Turbo Compressors for large capacities, as illustrated below.

WRITE TO DEPARTMENT "J" FOR PAMPHLETS GIVING FULL PARTICULARS.

REAVELL & CO., LTD.,
RANELAGH WORKS, IPSWICH.





"The best people" demand the best GLASSWARE and Ackroyd & Best manufacture and supply it.

At No. 98, Mansell Street, opposite the Royal Mint and the Tower of London, Messrs. Ackroyd and Best have now on view probably the largest and most varied display of glassware for every purpose ever housed under one roof in London. Now is the time to look to your lighting. Whether it is the home or the hotel, a theatre or cinema, make a point of visiting London's Glassware Headquarters, remembering that Ackroyd and Best have the newest and best in illuminating glassware. Every kind of globe, bowl, shade, vase, dish, stand lamp, toilet and trinket set on view—and every piece is made at Morley, nr. Leeds, by expert craftsmen who love their work.

Insist on "Hailglassware." Your local dealer can supply it. If any difficulty in obtaining, please write for name and address of nearest stockist.

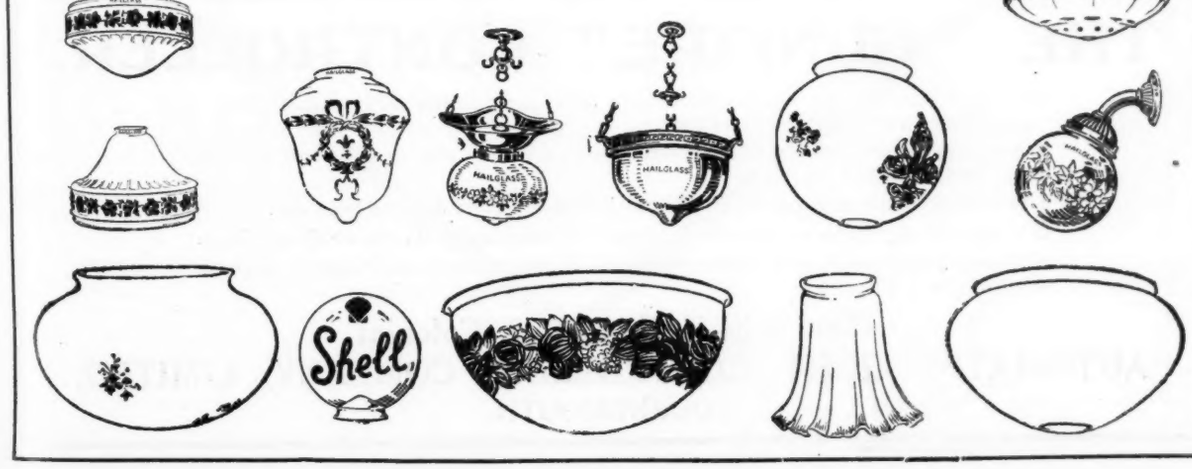
Mark Lane Station (District Railway) is within 3 minutes' walk of our showrooms.

ACKROYD & BEST, Ltd.

Head Office:

BEACON WORKS, MORLEY, nr. LEEDS.

London Office: **98, MANSELL STREET, E. 1.**



FOSTER & PULLEN LTD.
AVIL WORKS BRADFORD
AND 62 COWCROSS STREET LONDON E.C.1

PUBLIC LIGHTING
LANTERNS, PILLARS, BURNERS, MANTLES, CONTROLLERS AND ALL ACCESSORIES.
A SPECIAL FEATURE:
SIGNAL LANTERNS FOR MOTOR TRAFFIC.
CATALOGUE ON REQUEST.

THAMES BANK IRON COMPANY, Limited,

beg to announce they have taken more convenient and commodious premises and carry LARGE STOCKS of

BRITISH MADE: Cast Iron Pipes & Standard Fittings.

NOTE NEW ADDRESS:

LODGE RD., ST. JOHN'S WOOD, LONDON,

Telegrams: Hotwater, Eusroad, London. *Telephones: Paddington 7482, 7483, and 7484.* N.W. 8.

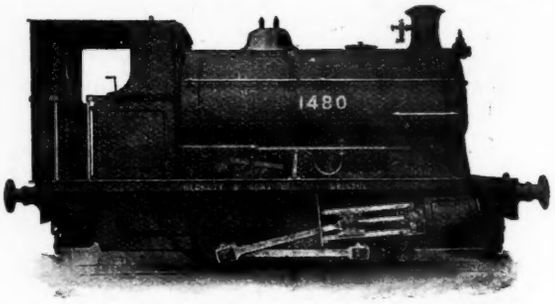
LOCOMOTIVES

LOCOMOTIVES of all Sizes and Gauges specially constructed for Main and Branch Lines, Contractors, Docks, Gas-Works, Collieries, Iron-Works, Brick and Cement Works, &c. Locomotives of various Sizes always in progress for early delivery.

Photographs, Specifications, and Prices on Application.

PECKETT & SONS, LTD., Atlas Locomotive Works, BRISTOL.

Telegraphic Address: "PECKETT BRISTOL."
London Representatives: FERGUSON & PALMER, 9, Victoria St., Westminster, S.W. 1.



THE "GUNFIRE" CONTROLLER.

The "GUNFIRE" has always been made both quick lighter and gradual since our 1899 Patents which clearly covers both.

We always recommend the gradual because we know they are the best, and sufficiently quick for all practical purposes.

The enormous sale of the gradual "Gunfire" over any other demonstrates this.

It is open for anyone to use the striking gear of an ordinary clock, but we do not do so.

If the bye-pass is properly adjusted the lighting is instantaneous, and there is no shock to the mantles.

The British, Foreign & Colonial
AUTOMATIC LIGHT CONTROLLING COMPANY, LIMITED,
BOURNEMOUTH.

For All Gas Works Plant!

ASHMORE, BENSON, PEASE & Co LTD
GAS PLANT MANUFACTURERS
PARKFIELD WORKS
STOCKTON-ON-TEES
LONDON OFFICE
39 VICTORIA ST WESTMINSTER S.W.

Ammonia Plants;
Benzol Plants;
Coolers;
Condensers;
Gasholders;
Gas Producers;
Livesey Washers;
Mains (Steel and Cast Iron);
Purifiers;
Roofs;
Stills;
Saturators;
Sulphate of Ammonia Plants;
Scrubbers;
Washers;
Water Gas Plants;
Naphthalene Extractors.

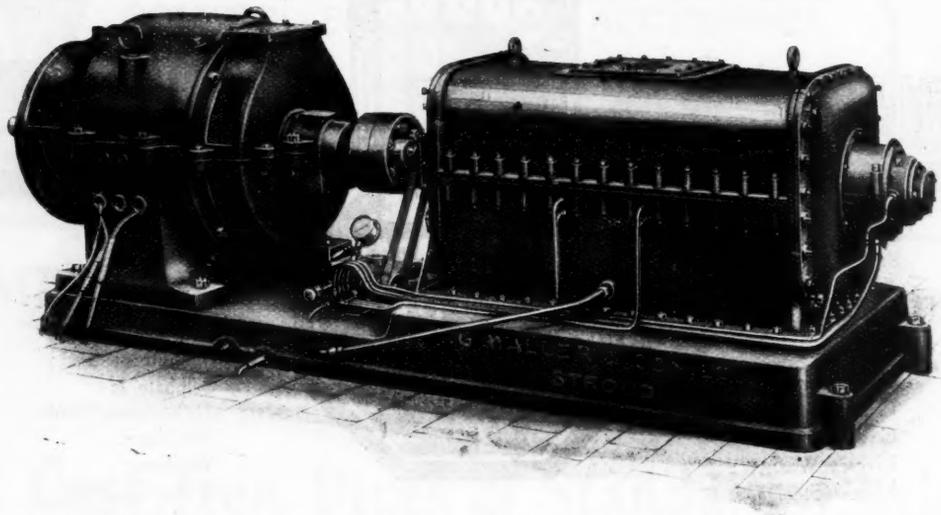
Telephones:
501 (3 lines) Stockton-on-Tees
8092 Victoria

Telegrams:
Gasholder," Stockton-on-Tees
"Tetratomic," London.

WE have been engaged for 50 years in the designing and manufacture of all manner of plant for Gas Works. Not only do we undertake contracts for small requirements, but our workshops are capable of executing orders of the largest dimensions in the shortest possible time. Let us have particulars of any Gas Plant that you may require so that we may quote you—you will find our prices reasonable

GAS COMPRESSORS & BOOSTERS

"MICHELL" PATENT CRANKLESS TYPE



"Michell" Compressor to deal with 200,000 cu. ft. of gas per hour at 5 lbs. per sq. in. pressure.

SPECIAL FEATURES.

High Efficiency.

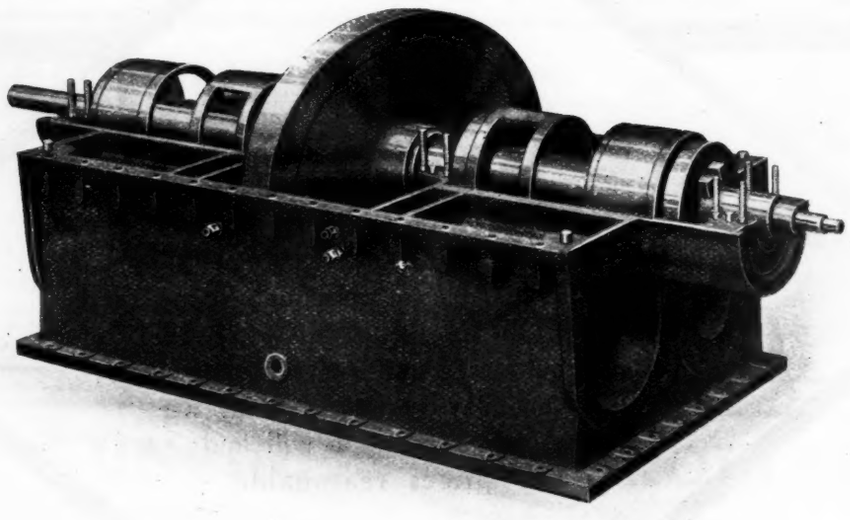
For size of Machine, very large Capacity of Gas dealt with.

Absolute Steadiness of Discharge.

Perfect Balance. No Vibration.

Low Running Costs.

Constant Efficiency over a large range of Volumes and Pressures.



The above Compressor with upper half of casing removed. Note the "slant" or swashplate, rotary valves, and cylinders in lower half of casing.

We have recently received an order from the Australian Gas Light Co., of Sydney, for seven half million cu.ft. per hour Boosters of this type for 7 lbs. per square inch pressure, which are to be driven by "Michell" Crankless Gas Engines.

GEO. WALLER & SON, Ltd.,

Phœnix Iron Works, STROUD, GLOS.

Telegraphic Address: "WALLER, BRIMSCOMBE." Telephone: 10 BRIMSCOMBE.

LONDON OFFICE: 149-150, PALACE CHAMBERS, S.W. 1. Telephone: 9476 VICTORIA.

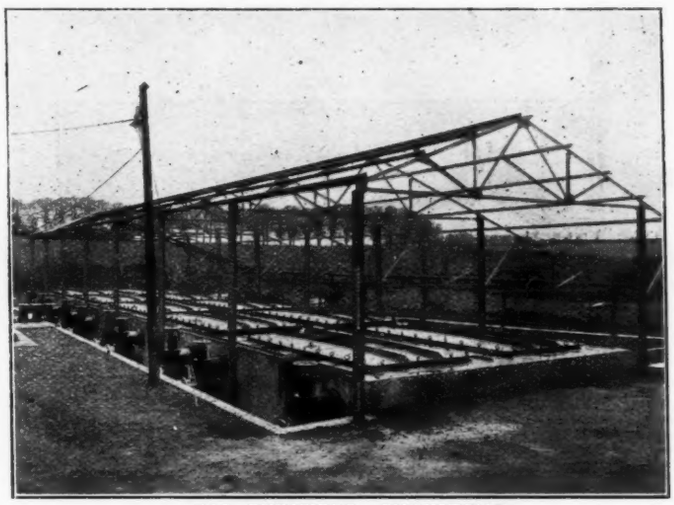
Agents for Scotland - - - MESSRS. D. M. NELSON & CO., 20, West Campbell Street, GLASGOW.

INDUSTRIAL CONSTRUCTIONS LTD.

Engineers and Contractors

REINFORCED CONCRETE A SPECIALITY

Telegrams: "Refcretcon, Phone, London."



Telephone: Victoria 6590 (3 lines).

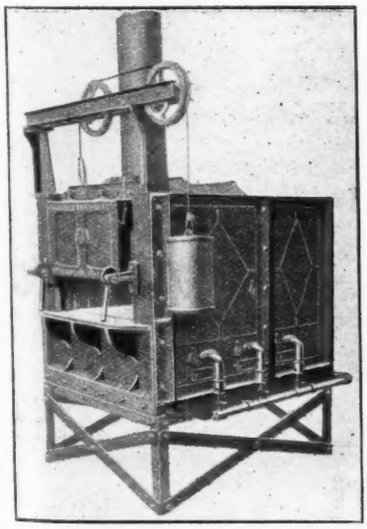
GAS PURIFIERS, CHRYSTON

Schemes and Tenders submitted without obligation

44, GROSVENOR PLACE, LONDON, S.W. 1

GAS FURNACES OVEN & MUFFLE

Improved Natural Draught Recuperative.



CAN BE OPERATED WITH OPEN DOOR WITHOUT HEAT REDUCTION OR ADMISSION OF COLD AIR INTO FURNACE CHAMBER.

AIR BLAST IS NOT REQUIRED FOR TEMPERATURES UP TO 1100° C. ALL GAS AND AIR SUPPLIES ARE UNDER COMPLETE CONTROL.

INVALUABLE FOR HARDENING TAPS AND DIES AND OTHER CARBON STEEL ARTICLES WHERE CONSTANT OBSERVATION IS NECESSARY.

AIR BLAST IS READILY APPLIED WITHOUT ALTERATION OF FURNACE. IT IS THOROUGHLY INSULATED AND THERE IS NOTHING COMPLICATED.

MAXIMUM ECONOMY & EFFICIENCY.

Made in all Sizes. Delivery from Stock.

ALSO

INDUSTRIAL FURNACES FOR ALL PURPOSES, COAL, COKE, PRODUCER GAS, TOWN'S GAS, AND OIL FIRED.

ECONOMY IN FUEL. UNIFORM HEATING. LOW MAINTENANCE COSTS. INCREASED PRODUCTION. IMPROVED QUALITY OF PRODUCT.

CASE HARDENING BOXES. CHARGING MACHINES. HEAT AND ACID RESISTING CASTINGS, &c., &c.

The INCANDESCENT HEAT Co., Ltd.

British Mills, Cornwall Road,

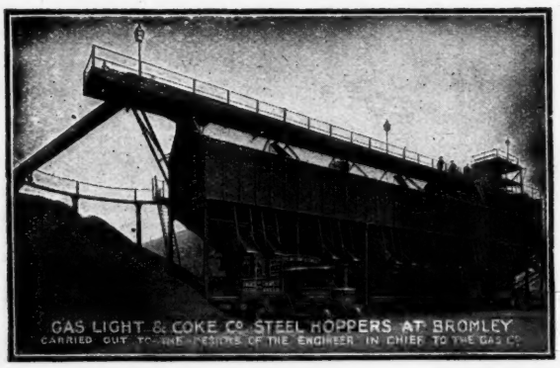
SMETHWICK, BIRMINGHAM.

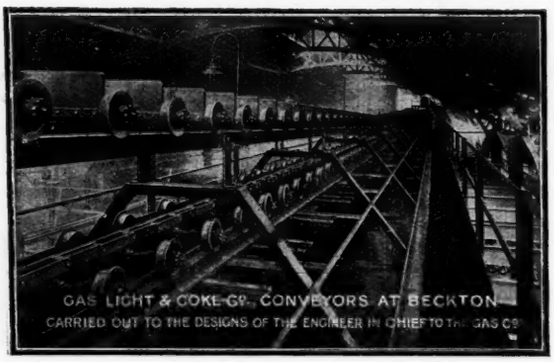
Telephone: Smethwick 276.
Telephone: "Repeat, Birmingham."

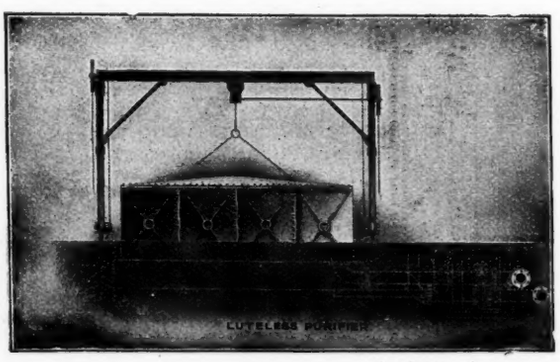
HEAD, WRIGHTSON, & Co., Ld.,

THORNABY-ON-TEES AND STOCKTON-ON-TEES.

SEND YOUR ENQUIRIES FOR PURIFIERS EITHER LUTELESS OR WATER SEALED







VALVES HYDRAULIC MAINS CONDENSERS SCRUBBERS WASHERS COKE CONVEYORS

CONSTRUCTORS OF

GASHOLDERS, GAS PLANT, ETC.

Syphon Pump

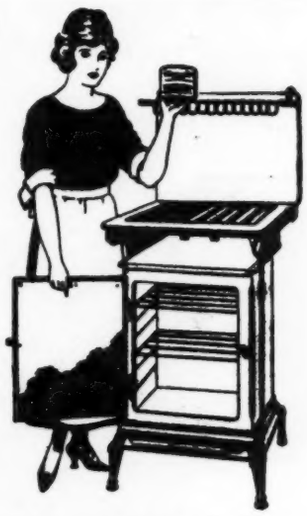
No. 1412

The pump illustrated above has been designed to enable us to put on the market a pump that will stand rough usage without being damaged.

REALLY AN EXCELLENT PUMP.
THE BEST ON THE MARKET.

MILTON HOUSE
MILNE
EDINBURGH

Branch Works:
Victoria Road,
Leeds.



"KLEENOFF"
Cooker Cleaning Jelly.

Removes Grease at Top Speed.
No Scouring Required.
The Hands need not be Soiled.
Retails at 10d. per tin.
Extra Strong, in bulk, for Works use.

The "KLEENOFF" Co. (Bale & Church, Ltd.)
(Dept. G.J.), 33, St. Mary-at-Hill, LONDON, E.C. 3.
Telegrams: "Balefire, London." Telephone: Royal 1484.

LOOK →

BEST RED PAINT from 22/6 per cwt.

Red Paint

Made with best Red Oxide of Iron and Linseed Oil.
Best for Protection and Appearance.

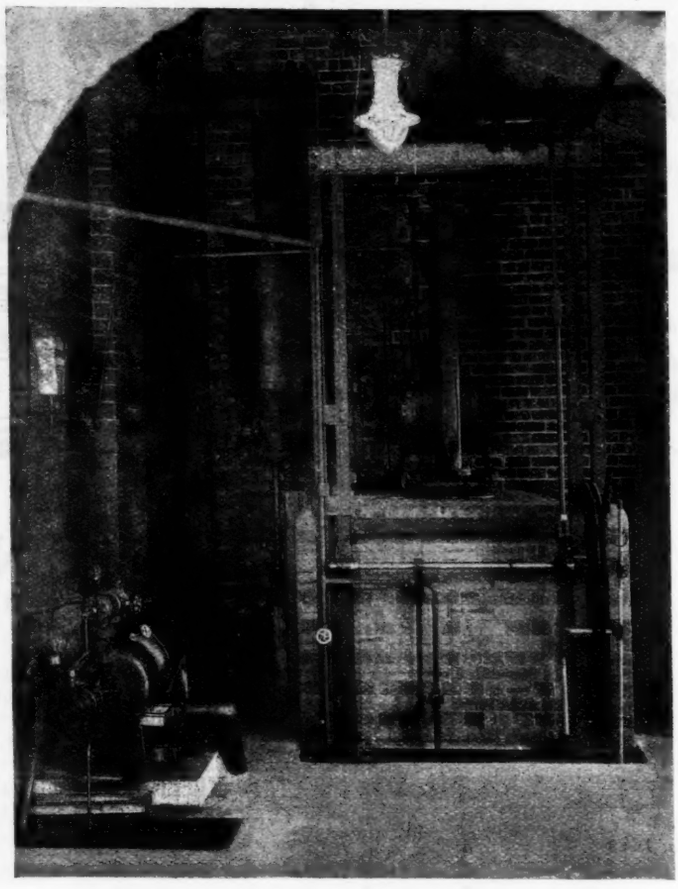
25/-	per cwt.	Ton lots.
26/6	,,	10 cwt.
28/6	,,	5 cwt.
31/-	,,	1 cwt.

All less 2/6 per cwt. for Cash with Order.
CARRIAGE PAID. :: DRUMS FREE.

Quotations for other Colours on application.

BITUMEN SOLUTION for Roads, Paths, etc.
CHEMICALS.
OXIDE OF IRON for GAS PURIFYING.

F. HULSE & CO., LTD.,
WOODLESFORD. : : : Near LEEDS.
Contractors to leading Councils, Railways, etc.
Send for free "SCIENCE BROCHURE."



CARDENDEN, 1925

"SIMPLEX" WATER GAS PLANTS

SIMPLE, EFFICIENT, LOW COST AND MAINTENANCE

"SYDENHAM" GRATES

ELIMINATE CLINKERING. NO STEAM REQUIRED

"SLOUGH" TAR DEHYDRATION PLANTS

TAR TO ROAD BOARD SPECIFICATION

"JAFFA" CHARGING MACHINES

RETORT BENCHES. IRONWORK. COAL PLANTS

The Vertical Gas Retort Syndicate, Ltd.

17, Victoria Street Westminster, S.W. 1

Telegrams :
"Vertigaret, Sowest, London"

Telephone :
Victoria 7498

It is significant that certain makers of Silica Bricks and Retorts have taken out a patent for "relieving arches" in retort cross walls, "to relieve the pressure which would otherwise distort or damage the retorts or other parts of the structure."

Why should Gas Engineers Run the Risk?

E. J. & J. PEARSON, LTD.'S

SPECIAL (F.R.D.)

High - Silica Firebrick Material

HAS NEGLIGIBLE EXPANSION.

Proved by frequent tests over a period of years, and confirmed by Dr. Mellor's report of August 17th, 1926, showing

0·06% Expansion

= less than ¾ of an inch in 100 feet.

F.R.D. is a proved success for Retorts and Cross Walls.

E. J. & J. PEARSON, Ltd., *Firebrick Manufacturers,*
STOURBRIDGE.

WINN'S

BACK-PRESSURE GAS VALVES

FOR USE WITH AIR-BLAST IN INDUSTRIAL AND OTHER GAS-HEATED APPARATUS

AS SUPPLIED TO THE

City of Birmingham Gas Department

AND OTHER GAS UNDERTAKINGS

NO MECHANICAL HINGE
DOES NOT STICK
DOES NOT AFFECT GAS PRESSURE

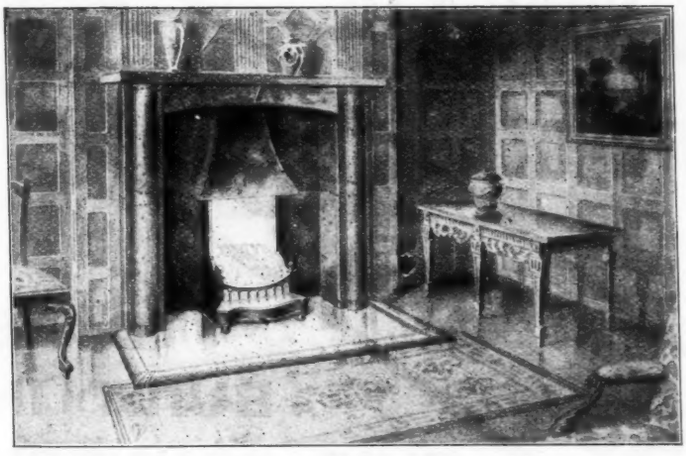
Write for particulars

CHARLES WINN & CO., LTD.

ST. THOMAS WORKS — GRANVILLE STREET

BIRMINGHAM

Established 1859



HARMONY. Art-Metal gives just that finishing touch to any scheme of decoration.

Our Art-Metal Surrounds and Mantelpieces are supplied in various finishes to harmonize with any colour scheme.

Art-Metal Surrounds for all types of gas-fires.

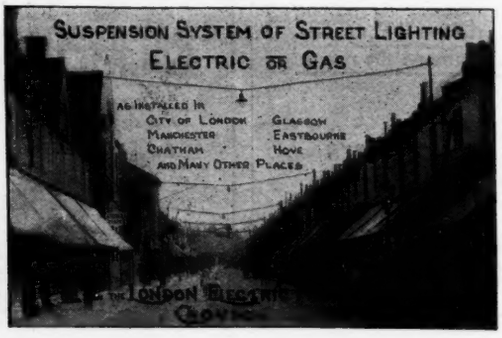
Complete Mantelpieces in Art-Metal.

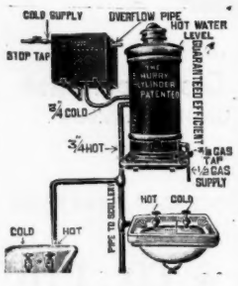
Hearths, Curbs, etc.

⊙ ⊙

Patentee and Sole Manufacturer of Turner's Adjustable Art-Metal Surround, as used by Gas Undertakings throughout the Kingdom.

F. TURNER
61, 62 & 63, Summer Hill Street,
BIRMINGHAM.





No. 10 CYLINDER.
Hot Water for Bath, Lavatory Basin, and Sink in Kitchen.

SMOKE ABATEMENT.

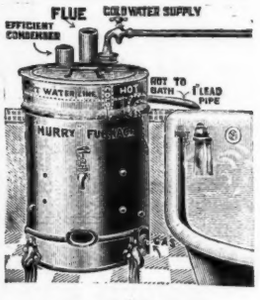
Two special designs of Patent "Hurry" Water Heaters, for parlour type and non-parlour type houses.

YOUR SAMPLE ORDER SPECIALLY INVITED.

Suppliers to large Housing Estates for many years where maintenance has to be considered.

Sole Makers and Patentees:—

THE HURRY WATER HEATER Co.,
39, BROAD STREET, BIRMINGHAM.



The MAGIC HURRY FURNACE.
For Washing Clothes, and also Hot Water to Bath on overflow method.

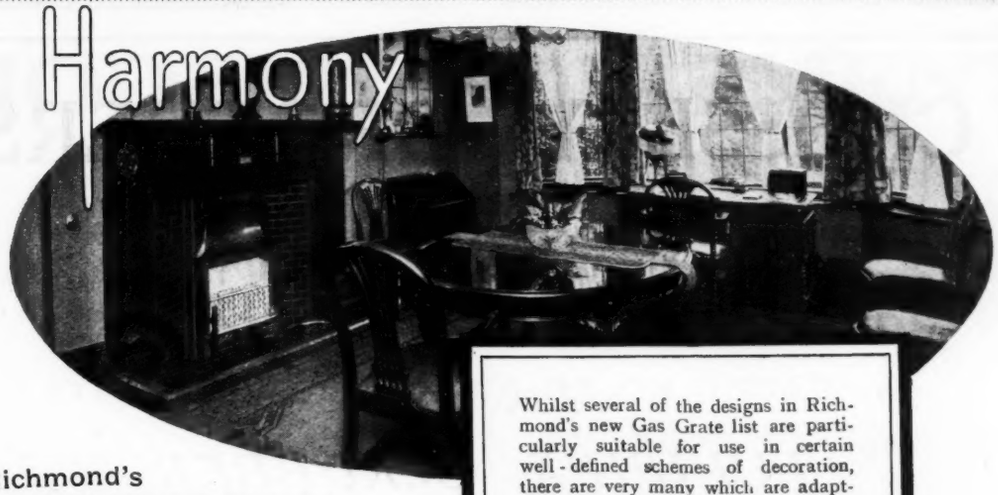
ED. COCKEY & SONS, LTD.,
ARE TO CONSTRUCT
THE FIRST
"WATERLESS" GASHOLDERS
TO BE BUILT IN THIS COUNTRY

THE IPSWICH GAS LIGHT AND COKE CO., LTD.,
2 Million Cubic Feet Capacity.
THE GAS LIGHT AND COKE COMPANY, LONDON,
Staines Works—1½ Million Cubic Feet Capacity.

ED. COCKEY & SONS, Ltd., FROME (Somerset).

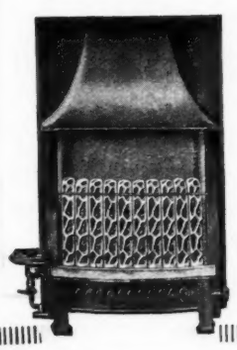
LONDON OFFICE: Tel. No.: Victoria 5238. Tel. No.: 16 Frome.
39, VICTORIA STREET. Telegrams: Edcosolim, Sowest, London. 'Grams: Cockeys, Frome.

Harmony



Whilst several of the designs in Richmond's new Gas Grate list are particularly suitable for use in certain well-defined schemes of decoration, there are very many which are adaptable to a wide range of interiors. Most noticeable among these is certainly the "Marlborough," which has yet to be introduced to a room that it will not adorn. It embodies the latest Radiation "Thermo XX" Fire-front, and patent "Injector-Ventilator."

Richmond's
"MARLBOROUGH"—



"—the chosen fire for Simple Hire."

The RICHMOND
Gas Stove & Meter Co., Ltd.,
164-172, Queen Victoria St., London E.C.4.
RADIATION, Ltd.,
Proprietors

TELEPHONES
LIVERPOOL BANK 4609
GLASGOW. CENTRAL 471
LONDON MUSEUM 7560/9.

MEMBERS OF THE NATIONAL UNION OF MANUFACTURERS INCORPORATED

TELEGRAMS
"FELANDER" LIVERPOOL.
"FELANDER" GLASGOW.
"LLEFANDERS" WESTCENT LONDON

FELL, ANDERSON & CO. LTD.

Chemical Plants **Technical Advisers**
Coal Tar Products **Ammonia Products**

ROAD TARS AND BINDERS

GAS PURIFYING MATERIALS

2, SOUTH JOHN STREET, LIVERPOOL

BRANCHES :—
GLASGOW—54, Gordon Street. LONDON—Sentinel House, Southampton Row, W.C. 1

CROSSLEY BROTHERS

Grid Works, BISPHAM, Lancs.

Makers of
PURIFIER, SCRUBBER
and WASHER GRIDS
of all types.

Telegrams: "Crossley," Bispham. **Telephone: 1339**

The
Perfect Control of District Pressures

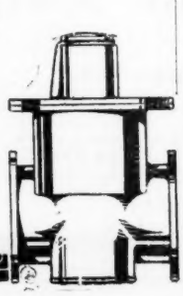
THE adoption of Peebles' District Governors will enable you to control the service pressure in the various areas to great degree of accuracy. Many Companies have adopted them and list of users increases rapidly.

These governors may be direct loaded by hand or by the Peebles system of pneumatic pressure from a distance, thus allowing the governor to be placed under the street, and being alterable without disturbing traffic.

The governor has other features and you should look into its merits, one of which is a saving in time and labour.

Write us about it.

PEEBLES & CO. LTD.
Tay Works
Bonnington
EDINBURGH



E.L.H.

INDUSTRIAL FURNACES

SURFACE COMBUSTION TYPE
and
RECUPERATIVE TYPE.

Furnaces of all sizes, Continuous and Intermittent, for Oil Distillation, Varnish Boiling, Heat Treatment of Steel, Roasting Kilns, Welding, Galvanizing, Carbonizing, Shipyard Work, Glass Melting and Annealing, Refractory Testing, Metal Melting, Asphalt Heating, Oil Tempering, Tar Boilers, Sugar Boiling, Etc.

Also
GAS FIRED BOILERS
and
WATER GAS PLANTS
for small Gas Works.

BRITISH FURNACES, Ltd.,
DERBY ROAD, CHESTERFIELD.

MODERN EQUIPMENT IN GAS WORKS

BABCOCK & WILCOX, Ltd., *manufacture*

CONVEYOR PLANT OF ALL KINDS

COAL & COKE CRUSHERS, WAGON TIPPLERS, &c.

Also . . .

WATER-TUBE STEAM BOILERS FOR UTILISING WASTE HEAT FROM GAS RETORTS.

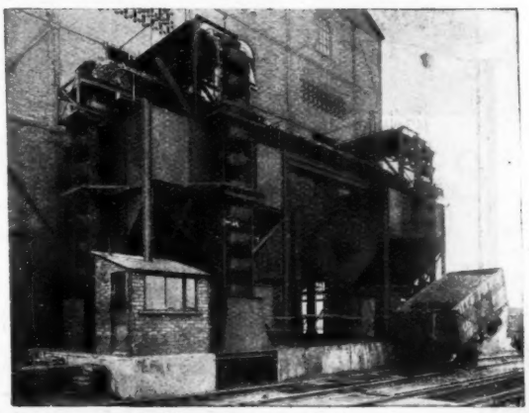
CATALOGUES ON APPLICATION.

Telegrams: Babcock, Cent, London." **Head Offices:** Telephone: City 6470 (8 lines).

Babcock House, Farringdon St., LONDON, E.C. 4

Principal Works: RENFREW, SCOTLAND.

Branch Works:
Dumbarton, Scotland; Oldbury & Lincoln, England, Australia & Japan.



Babcock and Wilcox Gravity Bucket Conveyors with Electric Wagon Tippers, installed at a northern Gas Works

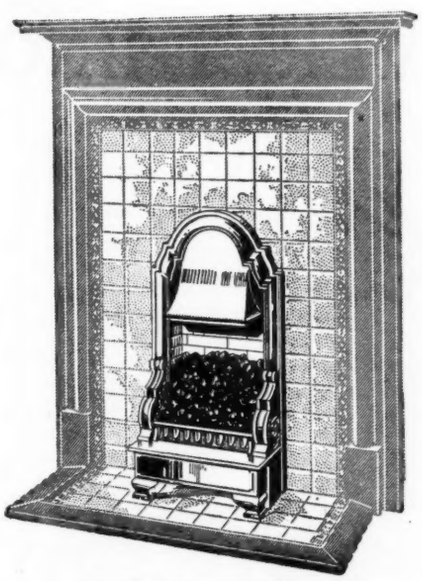
The ALLURING CHARM of a COAL FIRE

with the SIMPLICITY, CONVENIENCE and ECONOMY of using GAS is obtained only with a

SENTRY *Reg'd*

GAS FIRE

INSET ·:· SELF-CONTAINED ·:· DOG GRATE



The Self-Contained Pattern.

The "Sentry" Gas Fire, by reason of its construction, is the most economical fire produced. It fulfils all the requirements of the cosy fireside. A genial warmth, regulated at will, is radiated from this scientifically designed fire giving a sense of real comfort, with the nearest possible resemblance to a coal fire.

Existing Coal Grates are easily and inexpensively converted by fitting the "Sentry" Inset Gas Fire.

The simple and graceful design of the "Sentry" Gas Fire makes it suitable for any period of architectural decoration.

Telephone: MUSEUM 9341 (3 Lines).

WOOD, RUSSELL & Co., LTD.,
34, OXFORD STREET - - - LONDON, W.1.

Telegrams: "WOORUS, WESTCENT, LONDON."

(Also Makers of the well-known "SENTRY" Boilers).

The Mantle for British Homes

There may be cheaper brands of Gas Mantles—chiefly foreign—on the market, but there is none which gives better or longer lighting service than Welsbach.

The reason for this is that Welsbach Mantles are made to a quality—not a price! They could not be made cheaper without sacrificing the quality on which their reputation has been built.

Advt. of the Welsbach Light Company, Ltd., Welsbach House, King's Cross, London, W.C.1.

Branches at:
Birmingham,
Bristol,
Hull,
Leeds,
Manchester,
Stoke-on-Trent,
and Dublin.

WELSBACH
BRITISH MADE
GAS MANTLES

557.

Only

THE BEST OF EVERYTHING
IS USED IN THE MANUFACTURE OF

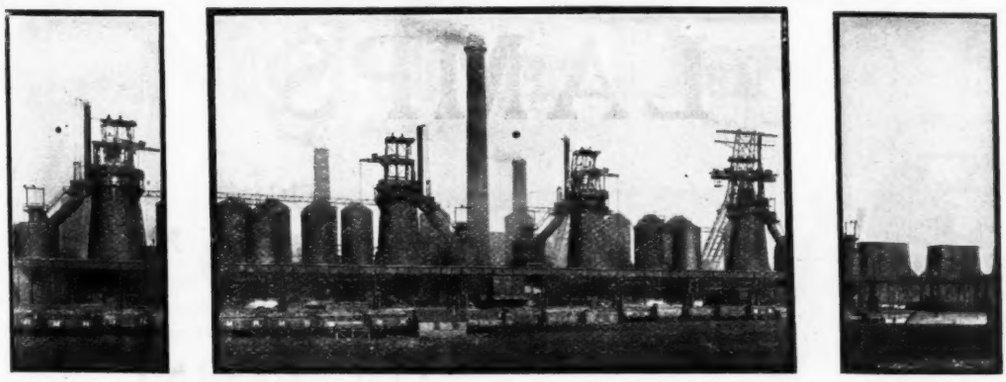
G.M.C.

METERS.

ESTABLISHED OVER 60 YEARS

THE
GAS METER COMPANY LTD.
238, KINGSLAND ROAD, LONDON, E. 2,
and *at* OLDHAM, DUBLIN, and MANCHESTER.

COLLIERY OWNERS



PIG IRON MANUFACTURERS

LONDON ADDRESS :—CROWN HOUSE, ALDWYCH, W.C. 2

Telegrams: "Stavironco, Estrand, London." Telephone: Regent 4846 (2 Lines).

Telegrams: "Staviron, Barrow Hill." THE Telephone: Chesterfield 251

STAVELEY

COAL & IRON CO., LD.

CHESTERFIELD

CHEMICAL MANUFACTURERS

MAKERS OF - - **CAST-IRON PIPES** FOR ALL - PURPOSES

"PARKINSON" LAMPS

FIG.
"1200"
ON
"U" FIXING
with metallised burners

The Ideal HIGH CANDLE POWER Gas Lighting Unit for the illumination of Promenades, Important Thoroughfares, Cross Roads, etc.

Metallisation——— ——A New Departure

The problem of corrosion and deposit on gas burners solved

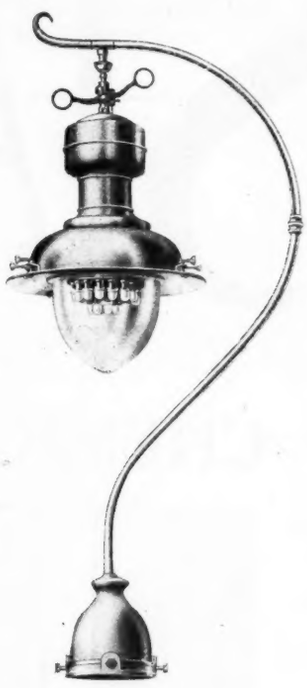
Metallised burners do not corrode and are immune from the effects of products of combustion

Great saving in mantle maintenance

Samples for trial on request.

FIG.
"1100"
SUSPENSION TYPE
with metallised burners

Can be supplied with Wrought Iron Swan Neck as illustrated, or Harp Fitting.



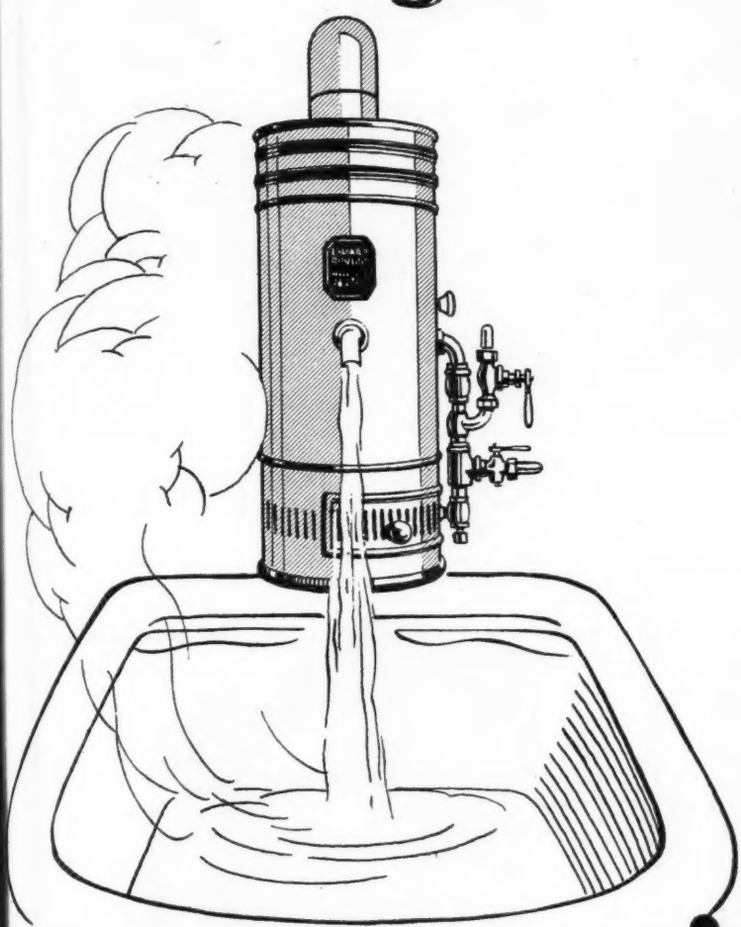
W. PARKINSON & CO.
(Incorporated in Parkinson & Cowan (Gas Meters) Ltd.)

BELL BARN ROAD :: :: BIRMINGHAM

And at

Cottage Lane, City Road, LONDON, E.C. 1

Hot Water Instantly Night or Day

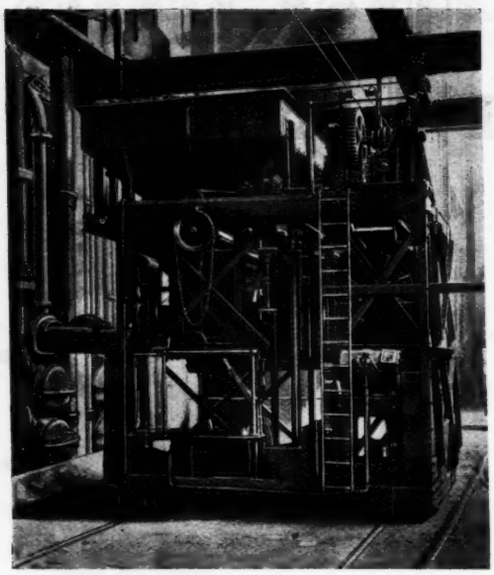


EWART'S 'LIGHTNING' GEYSER

346-350 EUSTON Rd. LONDON N.W.1

Established 1834

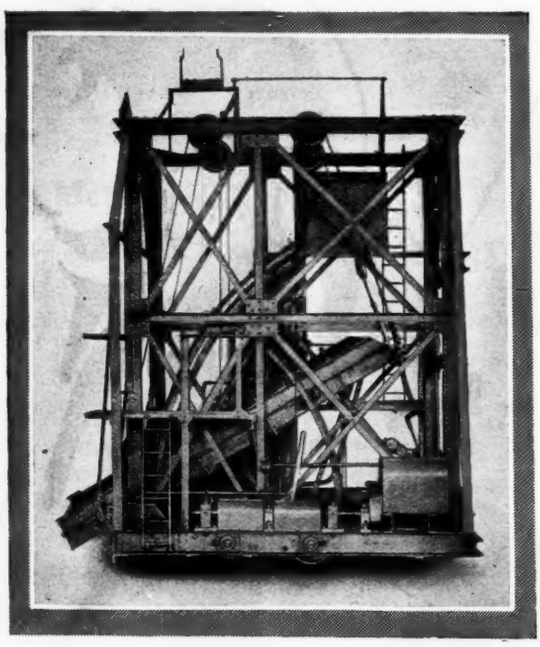
F.A. Stoking Machines.



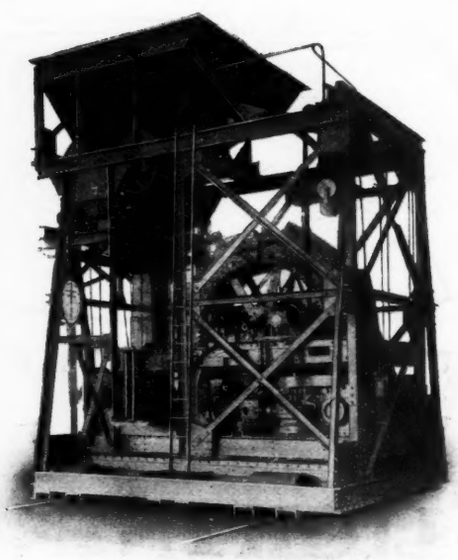
THE F.A. MULTIPLE-STROKE STOKING MACHINE

This Multiple - Stroke Stoking Machine occupies a small space, and has given the greatest satisfaction.

Especially suitable for small houses.



THE G.N. HOT-COKE HANDLING MACHINE and PRODUCER CHARGER



THE F.A. STOKING MACHINE AT SHANGHAI Fitted with Denison Weigher and Machine operated by Chinese Labour.

ALDRIDGE & RANKEN LIMITED

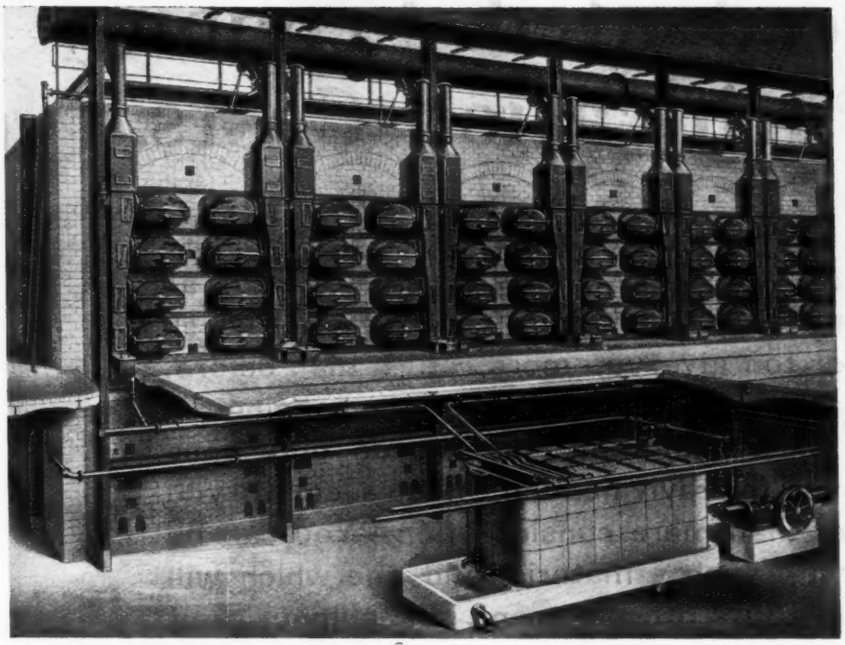
Patentees and Manufacturers

AVONBANK WORKS, BATH, England.

Telegrams: Simultane, Bath - - Telephone: 536 Bath.

LONDON OFFICE: 39, VICTORIA STREET, S.W. 1. - Telephone: 5118 Victoria Telegrams: Motorpathy, London.

Improved Congdon Scrubber Standpipe System



ADVANTAGES over ASCENSION PIPES, &c. :—

Right yield of Gas

Labour Saving

Cleanliness in operation

Saving in Auxiliary Plant

Existing Benches can generally be fitted with this system.

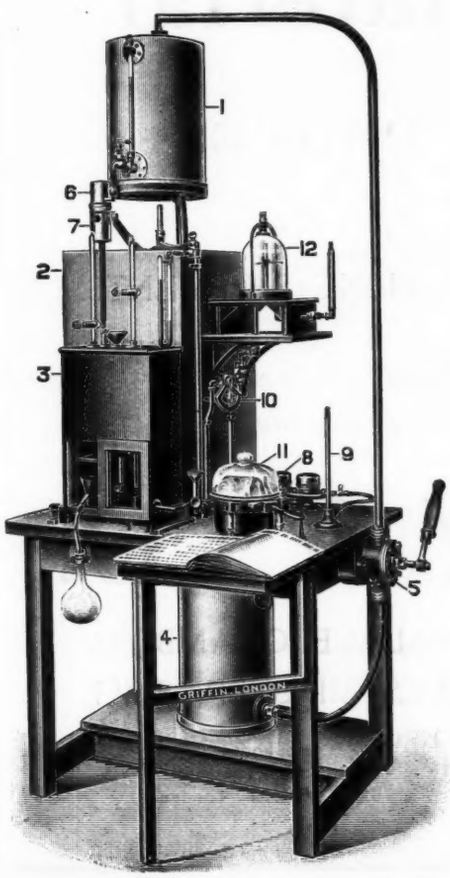
ALDRIDGE & RANKEN LIMITED

Patentees and Manufacturers

AVONBANK WORKS, BATH, England.

Telegrams: Simultane, Bath. - - Telephone: 536 Bath.

LONDON OFFICE: 39, VICTORIA STREET, S.W. 1. - Telephone: 5118 Victoria - Telegrams: Motorpathy, London.



The

BOX CALORIMETER

Patented 195,180/22.

DESIGNED BY PROF. C. V. BOYS, F.R.S.

The Gas Referees will prescribe it for Official Testings under the Gas Regulation Act.

Is quicker in action than other calorimeters.
Is less costly in upkeep than other calorimeters.
Is a complete testing place in itself.
Only requires a single gas connection.
Does not require any water pipes, sink, or waste pipe.
Can be placed anywhere in the works.
Cannot overheat with the normal flow of gas.
Can be arranged to take an instantaneous test at any time day or night. All necessary figures for a shortened test (one turn of meter) can be obtained within 3 minutes.

Makers :

JOHN J. GRIFFIN & SONS, LTD.,

KEMBLE ST., KINGSWAY,
LONDON, W.C. 2.

Unprecedented Economy in Purification Costs.

YOU have the purifying question often before you. You have considered it from all angles, and you want a purifying material which will ton for ton give you more return than before. A material which will reduce the changing of purifiers to a minimum, that needs only once turning over for revivification, must seem to you worth more than mere consideration. You can be supplied with such a material and one which will readily take up 60 per cent. of sulphur and increase the value of your spent material.

"LUX" Purifying Material

"A TRIAL WILL PROVE."

Delivery from Stock.

ORDER EARLY FOR INCLUSION IN NEXT SHIPMENTS.

Sole Sellers for England, Scotland, Ireland, Wales and the British Colonies (except Canada)

T. DUXBURY & CO.

16 DEANSGATE
MANCHESTER

Telegams:
"Darwinian, Manchester."
"Darwinian Parl, London."

PALACE CHAMBERS
WESTMINSTER, S.W.1

Telephone:
3268-9 City, Manchester.
6273 Victoria, London.

Loops of Heat!

These two successful new types of steamless radiators, with automatic control, are already sure of a foremost position in the coming season.

The "St. David"

Wright's "St. David" Radiator is fitted with a "Regulo" (*Regd.*) which maintains an even temperature under varying weather conditions. The usefulness of the "St. David" will thus be readily appreciated for warming Churches, Banks, Institutes, and large Public buildings. Each radiator forms a complete heating unit in itself, so that it is possible to limit the heating only to that part of the building that is in use, if necessary. The automatic gas control always ensures an even temperature, and counteracts the effect of draughts.

The "St. Bernard"

Wright's "St. Bernard" Radiator, in addition to having the ordinary advantages of radiator heating, has the greatly enhanced appearance given by the reflector device. The "St. Bernard" is particularly recommended for hotel corridors, lounges, and entrance halls. A pressure governor controls the gas consumption and automatically prevents the loop temperature from becoming excessive should gas-pressure vary. The scientific design of both the "St. David" and the "St. Bernard" makes it unnecessary for flues to be used excepting in small and ill-ventilated apartments.

Send for Illustrated Lists

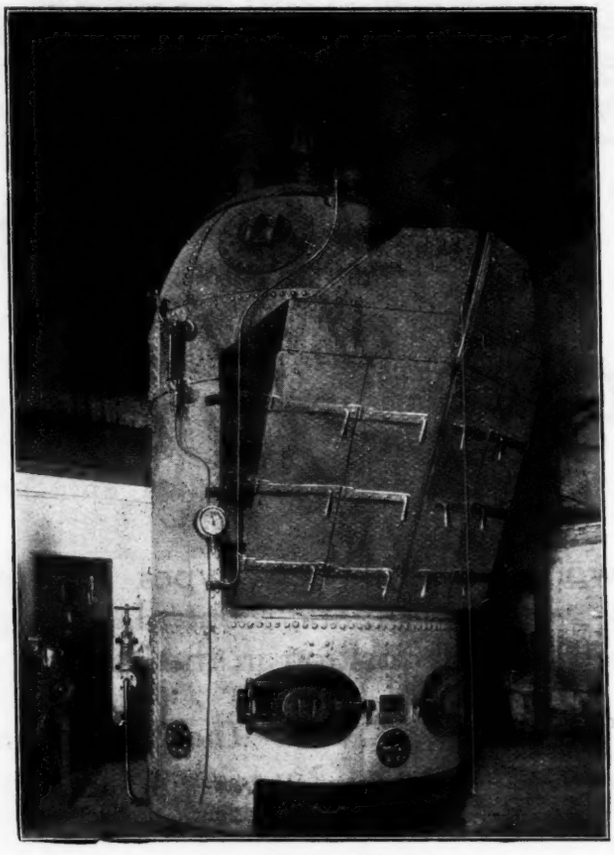
JOHN WRIGHT & CO.

Essex Wks · Aston · Birmingham (*RADIATION LTD. Proprietors*)

COCHRAN BOILERS

ARE ACKNOWLEDGED TO BE THE BEST DESIGNED & MOST POWERFULLY CONSTRUCTED BOILERS OF THE VERTICAL TYPE EVER OFFERED TO STEAM USERS AT HOME OR ABROAD

The COCHRAN BOILER was first put on the Market in 1878, and close on 10,000 units of sizes from 3 ft. to 8 ft. 6 in. dia. have been sold to WORLD - WIDE STEAM USERS, including a large number in BRITISH GAS - WORKS.



COCHRAN BOILER
8 ft. 6 in. dia. by 17 ft. high by 1000 sq. ft. H.S.
Working Pressure 125 lbs. per sq. inch.

Send for full particulars of COCHRAN GAS-FIRED BOILERS equipped with the well-known BURNER APPARATUS of Messrs. BRITISH FURNACES LTD.

We shall be glad to discuss WASTE - HEAT problems and submit proposals bearing on its utilisation as a fuel in suitably : : designed : : COCHRAN BOILERS.

The COCHRAN BOILER ILLUSTRATED ABOVE WAS RECENTLY INSTALLED at the Works of the NEW SOUTHGATE & DISTRICT GAS CO., MIDDLESEX. A Lancashire Boiler was initially considered, but the proposal was abandoned when it was realised that a Vertical Boiler exists which competes, on the basis of evaporative output, with Lancashire Boilers up to 30 ft. by 8 ft. The SAVING of SPACE in the BOILER HOUSE, of Brickwork SETTINGS, and the FACILITIES for internal cleaning are Features of the COCHRAN PROPOSITION which must appeal to all who require up to 6600 lbs. of STEAM PER HOUR from a single unit.

Head Office & Works:

COCHRAN & Co
ANNAN, LTD.,
ANNAN, SCOTLAND.

Telegrams. "MULTITUBE, ANNAN."
Telephone No. 2 ANNAN.

London Office:

7c LOWER BELGRAVE STREET, S.W.1.

Telegrams: "MULTITUBE, SLOANE, LONDON."
Telephone: 2467 VICTORIA.

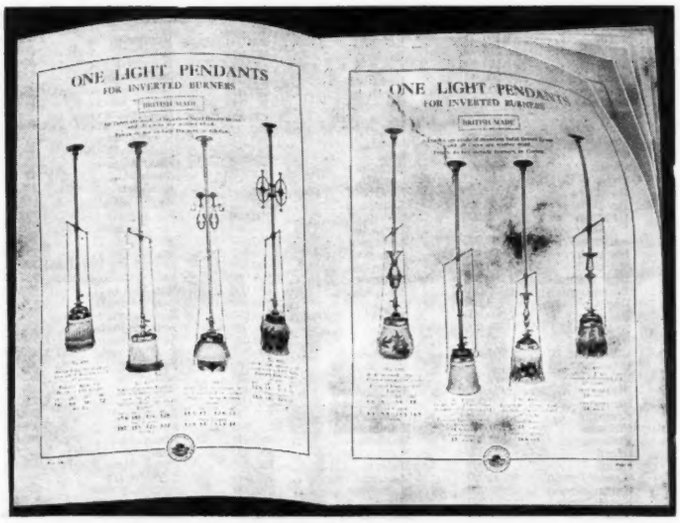
LIGHTING TRADES LIMITED · LONDON ·

AN INSTITUTION

from which you can promptly obtain supplies of reliable and efficient fittings for GAS LIGHTING at most reasonable prices. Every class of lighting is catered for — Public, Domestic, Industrial or Commercial.

We shall be pleased to quote you for

IRONCLAD, ZEIMAR, or VOLKER
GAS MANTLES
BURNERS : GLASSWARE
BRACKETS : PENDANTS
LAMPS, etc., etc.



This is an illustration of two pages from our new catalogue of Fittings.

If you have not yet received a copy please send a postcard to-day.

51-57, Garratt Lane, LONDON, S.W. 18

HUMPHREYS & GLASGOW, LTD.

WATER-GAS

	Cu. Ft. Daily
Aarhus	800,000
Abertillery	500,000
Abertillery	100,000
Admiralty:	
British	800,000
British	800,000
British	800,000
British	800,000
British	800,000
French	800,000
French	800,000
Agram	200,000
Airdrie	430,000
Aldershot	1,400,000
Aldershot	1,000,000
Alkmaar	400,000
Allenstein	200,000
Alost	700,000
Amersfoort	300,000
Amsterdam	1,000,000
Amsterdam	1,000,000
Amsterdam	2,700,000
Antwerp	1,500,000
Antwerp	1,000,000
Antwerp	1,500,000
Antwerp	1,900,000
Ascot	423,000
Ashford	250,000
Asnières	650,000
Augsburg	425,000
Aylesbury	150,000
Banbury	200,000
Banff	125,000
Barmen	500,000
Barnsley	588,000
Barrow	300,000
Barrow	500,000
Barry	500,000
Barry	720,000
Bath	1,000,000
Bath	1,000,000
Bath	1,300,000
Belfast	1,700,000
Belfast	4,500,000
Belfast	1,250,000
Belfast	1,250,000
Belfast	2,250,000
Benrath	125,000
Berkhampstead	259,000
Berlin:	
Charlottenb'g	2,500,000
Danziger Str.	1,600,000
Neukoelin	650,000
Neukoelin	700,000
Schmargendorf	760,000
Tegel	3,500,000
Tegel	6,350,000
Tegel	245,000
Bideford	258,000
Bilston	375,000
Bilston	125,000
Birmingham:	
Adderley St.	675,000
Nechells	3,000,000
Nechells	3,000,000
Nechells	3,000,000
Swan Village	1,500,000
Windsor St.	3,000,000
Windsor St.	3,000,000
Bishop's Stortford	300,000
Bishop's Stortford	300,000
Bishop's Stortford	200,000
Blackburn	1,190,000
Blantyre	150,000
Blois	125,000
Blois	125,000
Bochum	530,000
Bognor	100,000
Bognor	423,000
Bo'ness	125,000
Boulogne	340,000
Bournemouth	1,000,000
Bournemouth	500,000
Bournemouth	1,500,000
Bournemouth	1,000,000
Bournemouth	500,000
Bournemouth	1,530,000
Bournemouth	2,000,000
Bremen	550,000
Bremen	950,000
Bremen	850,000
Brentwood	250,000
Brescia	588,000
Brest	550,000
Bridgwater	200,000
Bridlington	150,000
Bridlington	200,000
Bridlington	550,000
Brieg	100,000
Brierley Hill	250,000
Brighton	1,750,000
Brighton	1,850,000
Brighton	750,000
Brighton	2,750,000
Bristol	2,000,000
Bristol	2,500,000
Bristol	1,700,000
Bromley	1,500,000
Bruges	200,000
Bruges	600,000
Brussels:	
Anderlecht	350,000
Anderlecht	350,000
Forest	1,000,000
Forest	1,000,000
Forest	1,000,000
Forest	1,500,000
Forest	88,000
Koekelberg	1,000,000
St. Gilles	1,000,000
St. Josse	1,000,000
St. Josse	600,000
St. Josse	775,000
Ville	750,000
Ville	750,000
Ville	1,500,000
Ville	350,000
Bucarest	1,100,000

	Cu. Ft. Daily
Buckie	164,000
Budapest	50,000
Budapest	1,750,000
Budapest	200,000
Budapest	250,000
Caen	250,000
Cambridge	500,000
Cambridge	1,000,000
Cardiff	2,000,000
Cardiff	3,000,000
Cardiff	1,950,000
Cardiff	600,000
Carlisle	600,000
Carlsruhe	500,000
Carnarvon	248,000
Charlerol	1,250,000
Châteauroux	125,000
Châteauroux	125,000
Châtelet	500,000
Chesterfield	430,000
Chesterfield	90,000
Chesterton	197,000
Chichester	250,000
Chorley	300,000
Cie. des Compteurs	1,150,000
Cie. Lorraine de Ch.	210,000
Cie. Mines de Roche	585,000
Coatbridge	400,000
Commercial, L'n	850,000
Commercial	850,000
Commercial	1,250,000
Commercial	2,000,000
Commercial	800,000
Commercial	2,100,000
Copenhagen	700,000
Copenhagen	2,500,000
Copenhagen	1,750,000
Courtrai	250,000
Coventry	600,000
Coventry	600,000
Coventry	800,000
Coventry	1,250,000
Coventry	350,000
Cowdenbeath	420,000
Cracow	200,000
Cracow	200,000
Crefeld	500,000
Crewe	700,000
Crewe	800,000
Crosfield & Sons	1,500,000
Crosfield & Sons	1,500,000
Crowborough	150,000
Croydon	1,250,000
Croydon	625,000
Croydon	625,000
Croydon	550,000
Croydon	650,000
Croydon	1,125,000
Croydon	150,000
Deal	250,000
Deal	250,000
Debreczin	100,000
Derby	1,500,000
Derby	2,000,000
Deventer	150,000
Deventer	200,000
Devonport	1,600,000
Devonport	1,100,000
Doncaster	1,350,000
Dorking	150,000
Dorking	300,000
Dover	500,000
Dublin	2,000,000
Dublin	2,000,000
Dublin	650,000
Dudley	600,000
Dundee	1,500,000
Dunedin, N.Z.	150,000
Dunedin	275,000
Durham	200,000
Dusseldorf	1,000,000
Eastbourne	1,250,000
Edinburgh	2,000,000
Eindhoven	1,500,000
Epsom	225,000
Epsom	300,000
Essen	1,400,000
Essen-Borbeck	1,400,000
Exeter	1,100,000
Exmouth	376,000
Falmouth	150,000
Faversham	200,000
Flensburg	300,000
Flensburg	125,000
Forst	300,000
Frankenthal	175,000
Fuel Research Wks.	500,000
Furnes	500,000
Gablonz	140,000
Gas L. & C. Co.:	
Beckton	10,000,000
Beckton	7,000,000
Beckton	3,500,000
Beckton	7,000,000
Beckton	7,000,000
Beckton	5,250,000
Beckton	4,500,000
Bow Common	1,000,000
Bow Common	1,150,000
Bow Common	150,000
Brentford	1,200,000
Brentford	850,000
Brentford	350,000
Brentford	750,000
Bromley	3,750,000
Bromley	2,250,000
Bromley	1,000,000
Bromley	1,000,000
Bromley	1,000,000
Fulham	2,500,000
Fulham	1,700,000
Ilford	650,000
Ilford	750,000
Kensal Green	2,250,000
Kensal Green	2,250,000
Kensal Green	2,250,000
Nine Elms	2,750,000

	Cu. Ft. Daily
Nine Elms	750,000
Nine Elms	1,870,000
Shoreditch	900,000
Shoreditch	2,700,000
Southall	2,030,000
Southall	3,000,000
Staines	600,000
Stratford	1,700,000
Stratford	850,000
Gelsenkirchen	175,000
Gelsenkirchen	350,000
Geneva	500,000
Geneva	700,000
Gennevilliers	10,600,000
Glasgow	3,000,000
Glasgow	2,500,000
Glasgow	2,250,000
Glossop	340,000
Gloucester	800,000
Gosport	200,000
Gosport	225,000
Göteborg	300,000
Göteborg	600,000
Graudenz	200,000
Grays	250,000
Grays	400,000
Guest Keen & Piggotts, Ltd.	1,936,000
Guildford	350,000
Guildford	200,000
Guildford	350,000
Guildford	1,100,000
Haarlem	850,000
Hamburg	1,750,000
Hampton Court	500,000
Hampton Court	600,000
Hampton Court	1,100,000
Hanley	800,000
Hanley	800,000
Hartlepool	750,000
Hartlepool	765,000
Hebden Bridge	200,000
Heidelberg	200,000
Hereford	525,000
Hertford	197,000
Hertford	244,000
Hessle	150,000
Hilversum	850,000
Hinckley	250,000
Holyhead	197,000
Hong Kong	450,000
Hong Kong	450,000
Hornsey	2,750,000
Hornsey	750,000
Horsham	235,000
Hull	1,500,000
Hull	1,000,000
Innsbruck	200,000
Ipswich	750,000
Ipswich	1,250,000
Jersey	564,000
Kampen	350,000
Karlsbad	350,000
Kendal	329,000
Kidsgrove	235,000
Kiel	1,000,000
Kiel	880,000
Kilmarnock	500,000
Kilmarnock	585,000
King's Lynn	197,000
Kirkintilloch	360,000
Kirkintilloch	827,000
Kolozvar	100,000
Lancaster	500,000
Largs	235,000
Lausanne	250,000
Lausanne	385,000
Le Mans	420,000
Lea Bridge	350,000
Lea Bridge	350,000
Lea Bridge	400,000
Lea Bridge	1,000,000
Lea Bridge	1,500,000
Lea Bridge	1,530,000
Leamington	600,000
Leamington	525,000
Leeds	1,500,000
Leeuwarden	400,000
Leiden	500,000
Leiden	575,000
Leigh	350,000
Lemberg	260,000
Lemberg	500,000
Letchworth	362,000
Letchworth	423,000
Liége	1,000,000
Liége	750,000
Lille	860,000
Lincoln	500,000
Lincoln	893,000
Liverpool	3,500,000
Liverpool	4,500,000
Liverpool	750,000
Liverpool	1,750,000
Liverpool	1,250,000
Liverpool	3,000,000
Liverpool	1,500,000
Liverpool	1,250,000
Long Eaton	430,000
Longton	600,000
Louvain	800,000
Lubeck	400,000
Luton	400,000
Maastricht	200,000
Macclesfield	800,000
Magdeburg	1,400,000
Maidenhead	225,000
Maidenhead	225,000
Maidenhead	175,000
Maidenhead	175,000
Maidstone	500,000
Maidstone	500,000
Malines	500,000
Malines	575,000
Malmö	350,000
Malta	400,000
Manchester	3,500,000

	Cu. Ft. Daily
Manchester	3,500,000
Manchester	1,500,000
Mansfield	330,000
Mansfield	493,000
Marlborough	100,000
Mayence	700,000
Merthyr Tydfil	300,000
Merthyr Tydfil	200,000
Middlesbrough	1,250,000
Middlesbrough	750,000
M/M. Woolston	9,000,000
Monaco	275,000
Mons	500,000
Morecambe	333,000
Moscow	1,000,000
Munich	1,400,000
Namur	175,000
Narbonne	350,000
Nelson	400,000
Neuss	140,000
Newbury	250,000
Newcastle, N.S.W.	500,000
Newport Pagnell	188,000
Nice	900,000
Nictheroy	250,000
N. Middlesex	150,000
N. Middlesex	200,000
N. Middlesex	75,000
N. Middlesex	650,000
N. Middlesex	650,000
N. Middlesex	1,000,000
North Sydney	500,000
North Sydney	500,000
Norwich	1,000,000
Norwich	300,000
Norwich	500,000
Norwich	1,500,000
Nottingham	1,000,000
Nottingham	1,000,000
Nuneaton	125,000
Oberhausen	175,000
Oldbury	500,000
Oldenburg	200,000
Ormskirk	170,000
Ostend	100,000
Ostend	200,000
" Zandvoorde	700,000
Paris:	
Clichy	4,000,000
Ivry	1,570,000
Landy	6,000,000
Landy	6,000,000
La Villette	4,000,000
La Villette	2,000,000
St. Mandé	1,570,000
Paris-Plage	125,000
Pau	550,000
Pembroke	240,000
Perigueux	350,000
Perth, W.A.	125,000
Piggott & Co.	1,500,000
Plymouth	2,000,000
Poitiers	350,000
Pontypool	120,000
Port Elizabeth	400,000
Portsmouth	1,000,000
Portsmouth	2,000,000
Portsmouth	800,000
Posen	450,000
Posen	700,000
Prague	140,000
Preston	1,400,000
Ramsgate	430,000
Reading	1,000,000
Reading	1,000,000
Reading	600,000
Redditch	500,000
Redhill	275,000
Redhill	300,000
Redhill	1,100,000
Reichenberg	200,000
Reichenberg	200,000
Reval	350,000
Rhymney	175,000
Rhymney	250,000
Riddings	258,000
Ripley	120,000
Rochester	2,200,000
Rochester	2,800,000
Romford	300,000
Romford	350,000
Rotterdam	850,000
Rotterdam	1,500,000
Rotterdam	750,000
Rotterdam	750,000
Rotterdam	600,000
Rotterdam	2,000,000
Royston (Yorks.)	250,000
Rugby	1,000,000
Rushden	425,000
Rushden	517,000
Saffron Walden	235,000
St. Albans	700,000
St. Andrews	210,000
St. Gallen	225,000
St. Gallen	225,000
Ste. Ch.Gr. Paroisse	1,320,000
Sté. Tubes Meuse	545,000
San Paulo	700,000
Scarborough	300,000
Scarborough	200,000
Scarborough	350,000
Scarborough	1,300,000
Scarborough	1,350,000
Seaford	200,000
Shanghai	225,000
Shanghai	225,000
Shanghai	1,600,000
Shanklin	259,000
Sheerness	200,000
Sheerness	180,000
Sheffield	1,530,000
" Steel Prods.	5,000,000
Shrewsbury	300,000
Sittingbourne	259,000
Southampton	800,000
Southampton	500,000

	Cu. Ft. Daily
Southampton	600,000
Southampton	100,000
Southampton	1,000,000
Southend	1,250,000
Southend	900,000
Southend	900,000
Southgate	400,000
Southgate	500,000
Southgate	800,000
Southgate	500,000
Southport	750,000
Southport	900,000
Southport	900,000
Southport	450,000
South Shields	650,000
South Shields	1,250,000
Stafford	500,000
Stettin	880,000
Stirling	400,000
Stockholm	1,500,000
Stockholm	1,750,000
Stockport	600,000
Stockport	600,000
Stockport	400,000
Stockport	400,000
Stockton	500,000
Stockton	250,000
Stourbridge	500,000
Stourbridge	500 000
Sunderland	2,250,000
Sunderland	300,000
Swansea	750,000
Swansea	1,000,000
Swansea	450,000
Swansea	1,250,000
Swansea	2,000,000
Swindon	300,000
Swindon	450,000
Sydney	1,000,000
Sydney	1,000,000
Sydney	1,000,000
Sydney	1,000,000
Taunton	225 000
Taunton	350,000
Teignmouth	200 000
The Hague	1,000,000
The Hague	500,000
The Hague	1,750,000
The Hague	1,500,000
The Hague	775,000
The Hague	1,500,000
Tilburg	400,000
Tirlemont	120,000
Tokyo	2,000,000
Torquay	350,000
Torquay	350,000
Torquay	320,000
Tottenham	750,000
Tottenham	750,000
Tottenham	350,000
Tottenham	1,000,000
Tottenham	1,000,000
Tottenham	1,250,000
Tottenham	2,500,000
Tottenham	1,000,000
ToulouseNatl. Wks.	2,400,000
Tournai	700,000
Tours	550,000
Trowbridge	250,000
Tunbridge Wells	1,000,000
Tunbridge Wells	1,000,000
Tunis	175,000
Tynemouth	1,100,000
Tynemouth	1,100,000
Ulm	400,000
Utrecht	1,000,000
Utrecht	1,000,000
Uxbridge	752,000
Verviers	1,000,000
Vienna	3,500,000
Vienna	2,500,000
Walsall	750,000
Waltham	400,000
Waltham	140,000
Wandsbek	125,000
Wandsworth	1,800,000
Wanganui, N.Z.	376,000
Ware	150,000
Warwick	125,000
Wasmuel	500,000
Watford	300,000
Watford	350,000
Watford	400,000
Wath	430,000
Weimar	100,000
Wellingborough	525,000
Wellingborough	525,000
Wellington, N.Z.	350,000
West Bromwich	550,000
Westgate	250,000
Weston-Mare	350,000
Weston-Mare	350,000
Weston-Mare	150,000
Weston-Mare	150,000
Wexford	100,000
Weymouth	400,000
Weymouth	100,000
Weymouth	638,000
Widnes	500,000
Wiesbaden	850,000
Winchester	225,000
Winchester	125,000
Winchester	410,000
Woking	400,000
Wolverhampton	1,500,000
Wolverhampton	1,000,000
Wolverhampton	250,000
Wolverhampton	400,000
Worthing	525,000
Yarmouth	500,000
Yarmouth	125,000
Yeovil	340,000
Zwolle	200,000
Zwolle	200,000
Zwolle	700,000

793 *Sets of Humphreys-Glasgow Plant have been (and are being) installed with a capacity of over* **597,000,000** *cubic ft. of Water-Gas per diem. Including the work of their American Colleagues,* **1829** *Sets have been constructed with a total* **DAILY** *capacity of* **1,774,000,000** *cubic feet.*

Head Office: 38, VICTORIA STREET, LONDON, S.W. 1.

CONTENTS.

EDITORIAL NOTES.

Impressions at the Institution Meeting . . 751
The Physical Conditions of the Charge . . 752
Economical Works Development 753
Service to the Consumer 754
Developing the Outer Areas 755
The Twenty-First—Place of Next Institution Meeting—Miners' Federation Move . . 756
The Proposals—Summer Time Extension . 757

East Greenwich War Memorial—Unveiled by Dr. Charles Carpenter 757
Personal 758
Obituary—Frederick A. Pye 758
Forthcoming Engagements 758
Western Junior Gas Association 758

INSTITUTION OF GAS ENGINEERS.

ANNUAL MEETING IN LONDON—
Review of the Proceedings 759
A Few More Snapshots 763
Social Events—
The President's Reception 772
The Luncheon 772
The President's Glyne Gap Works, Hastings 774
General Report—
The President and his Work—Confirmation of Minutes—Appointment of Scrutineers—H. E. Jones "London" Gold Medal—The Diplomas—New Honorary Members 777
The Reception—An Addendum to the President's Address 778

General Report (*continued*)—
Acknowledgments to Mr. Botley . . . 779
Annual Report and Accounts—Annual General Meeting of the Benevolent Fund—Report of the Advisory Committee on Education—Gas Investigation Committee—Welcome to Colonial Visitors 780
Greetings from the French Society of Gas Engineers—Good Wishes from France—Portslade (Brighton) Gas-Works—New Members 781
Further Telegrams—List of New Officers—Carbonization in Continuous Verticals—A Warning—Refractory Materials Report—Service to Consumers—Gas Research Fellowship Report—Gas Distribution at High Pressure—The New President—Presidential Certificate . 782
Votes of Thanks—Place of Next Meeting 783
The Secretary—The President's Services 784
Education Scheme—Report of the Advisory Committee for the Year 1925-26 . . . 785
Fifteenth Report of the Research Sub-Committee of the Gas Investigation Committee of the Institution of Gas Engineers 787
Sixteenth Report of the Research Sub-Committee of the Gas Investigation Committee 802
The Development and Reconstruction of the Portslade (Brighton) Gas-Works. By C. H. Rutter, M.Inst.C.E. 828
Investigation of Some of the Factors Affecting Carbonization in Continuous Vertical Retorts. By T. F. E. Rhead, M.Sc., A.I.C. 843

Institution Meeting (*continued*)—
Report of the Refractory Materials Joint Committee 862
Service to the Consumer. By John W. McLusky and W. B. McLusky . . . 867
Institution Gas Research Fellowship, 1926—Influence of the Ash Constituents in the Carbonization and Gasification of Coal. Part II.—Gasification of Special Cokes in Steam. By C. B. Marson, Ph.D., M.Sc., A.I.C. (Gas Research Fellow), and J. W. Cobb, C.B.E., B.Sc., F.I.C. (Livesey Professor) 882
Distribution of Gas at High Pressure. By Arthur W. Sumner, A.M.I.Mech.E. . . 894
Evening Star Lodge, No. 1719—Emergency Meeting 776

MISCELLANEOUS NEWS.

North-East Coast Coal Trade 758
Coal Trade in the Midlands 758
Yorkshire and Lancashire Coal Trade . . 758
Current Sales of Gas Products 758
Stock Market Report 903

PARAGRAPHS.

Erratum—Wales and Monmouthshire District Institution 757
Dorking Gas Company 758

"JOURNAL" OFFICE TELEPHONE.

The "Journal" Office Telephone Number is "Central 6055."

For List of "JOURNAL" Advertisers, see p. 907.

G.J. 29-9-26.

RECIPROCITY.

Gas melts Aluminium.
Aluminium helps Gas

WITH

FITTINGS
(Burners, Globe-holders and Deflectors, Diffusers, Lamp-cases, etc.) which are economical and keep colour well.

OVEN LININGS
which save enamelling, clean easily, last well, and are decidedly economical.

KITCHEN UTENSILS
which heat speedily, save expense and labour, and are permanently hygienic.

ELECTRIC CONDUCTORS
which withstand sulphur and ammonia fumes.

ROOFING
with similar properties.

HANDBOOK OF

Aluminium

DATA FREE FROM

THE BRITISH ALUMINIUM Co., Ltd., Aluminium Producers, Adelaide House, London, E.C. 4.

The THOMAS GLOVER Service

PARKINSON'S

PREPAYMENT METERS.

UNSURPASSED FOR QUALITY.

FITTED WITH LONG RANGE ATTACHMENT.

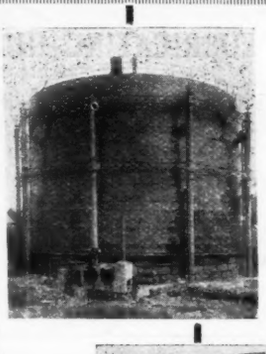
Outside Valve, Easily Accessible for Cleaning.

W. PARKINSON & CO.,

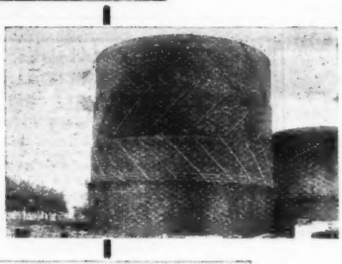
INCORPORATED IN PARKINSON & COWAN (GAS METERS), LTD.

COTTAGE LANE, CITY ROAD, LONDON, E.C.1.	BELL BARN ROAD, BIRMINGHAM.	MORNINGTON STREET, ORMEAU ROAD, BELFAST.
Telegrams: "INDEX, ISLING, LONDON."	"GASMETERS, B'HAM."	"PREPAYMENT, BELFAST."
'Phone Nos.: 4270 Clerkenwell	2345 Midland, B'ham.	3374 Belfast.

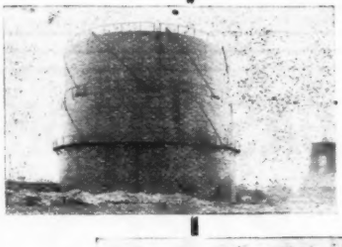
NEW GAS PLANT



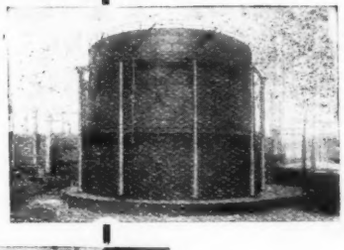
250,000 c.ft. capacity Column-Guided Gasholder, with Spiral - Guided Inner-lift.



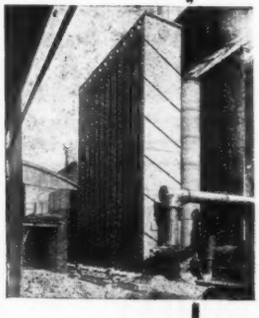
500,000 c.ft. capacity Spiral-Guided Gasholder.



200,000 c.ft. capacity Spiral-Guided Gasholder.



200,000 c.ft. capacity Column Guided with Spiral Inner-lift.



1,000,000 c.ft. per day capacity Patent Baffle Plate Condensers.

FOUR SOUND REASONS

WHY WE ARE QUALIFIED TO ERECT YOUR NEW PLANT

1. OUR PLANT AND MACHINERY. Modern and fully up-to-date equipment assuring you of speed and accuracy in the manufacture and erection of your new installation.
2. OUR ORGANIZATION. Comprised of men who, with many years of practical experience, have become experts, and who fully realize that efficiency in all things serves them best.
3. DESIGN. Whatever your requirements may be, in respect to design, type, capacity, strength, pressure, etc., our engineering personnel guarantees fulfilment.
4. RANGE. We have erected Gasholders from the Orkneys to Cornwall. No matter where your works are situated, we can fulfil your requirements and satisfy you, both in regard to quality and price.

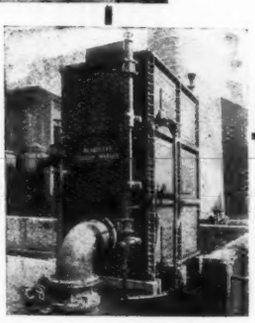
When installing your next Gasholder specify the "Woodall-Duckham" Patent Gasholder Inlet Pipe. By its adoption a uniform and perfect mixture is obtained.

Other Specialities:

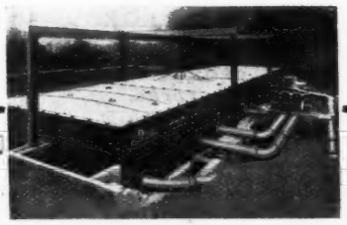
"VULCAN" PATENT REVERSING VALVES FOR PURIFIER INSTALLATIONS. These valves embrace every sequence of operations, as also upward and downward flow. *Any* one or more purifiers can be cut out or reversed at will.

Write for Illustrated Descriptive Leaflet.

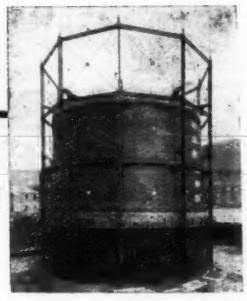
BLAKELEY'S PATENT BAFFLE-PLATE CONDENSERS. Admitted to be the most efficient atmospheric condensers ever designed. At least 90 per cent. of the Tar eliminated. Made in capacities from 5,000 to 5,000,000 cubic feet per day.



Patent Multiple Livesey Washer. 1,000,000 c.ft. per day capacity.



Four 15 ft. 0 in. square Purifiers.



200,000 capacity Column - Guided Gasholder.

FIRTH BLAKELEY, SONS, & CO., LTD.,

Gas Plant Engineers,

Vulcan Iron Works, CHURCH FENTON, YORKS.

ROBERT DEMPSTER & SONS, Ltd., ELLAND, Builders of CARBONIZING PLANTS, both Horizontal and Vertical. Manufacturers of CONDENSERS, PURIFIERS, GASHOLDERS, &c., also every description of COAL and COKE HANDLING PLANT. Telegrams: "DEMPSTER, ELLAND." Telephone: ELLAND 261 (Private Branch Exchange).

EXTENSIONS and Renewals. Ask us to quote before ordering GAS APPARATUS, COKE-OVEN PLANT, STRUCTURAL STEELWORK. Competitive prices, First-Class Workmanship. Satisfaction Guaranteed.
FIRTH BLAKELEY, SONS, & CO., LTD., CHURCH FENTON, YORKSHIRE.

HANDLING INSTALLATIONS COMPLETE for all classes of Material. TELPHERS, AUTOMATIC SKIP HOISTS, SCREENS (Stationary and Portable), TRUCK TIPPERS, CONVEYORS, SKIPS, GRABS, &c.
STRACHAN & HENSHAW, LTD.,
WHITEHALL IRONWORKS, BRISTOL.
Wires: "STRASHAW, BRISTOL." 'Phone: 432 BRISTOL.

PLANT, &c., FOR SALE.

(Continued.)

FOR SALE.—One new high-grade quality India Rubber CHARGING BELT, for De Brouwer Machine, 13 ft. 9 in. endless, 15 in. wide, 8 in. raised path, for £8.
Apply, JAS. RUSSELL & CO. (NEWCASTLE), LTD., WESTGATE RUBBER WORKS, NEWCASTLE-ON-TYNE.

GAS-WORKS Plant. We Purchase, for Dismantling, for Re-Use or Scrap, any DISCARDED PLANT or IRONWORK. Best prices, prompt removal by experienced staff, covered by insurance for all risks.
FIRTH BLAKELEY, SONS, & CO., LTD., Second Hand Plant Department, CHURCH-FENTON, *via* LEEDS.

FOR SALE—16 New ⌂ Retorts by Mobberley and Perry, 22 in. by 16 in. by 10 ft. 4 in. long, open ends, Six Bolt Holes.
Offers f.o.r. to C. G. DAWSON, GAS-WORKS, PAIGNTON.

FOR SALE—Four Purifiers, 18 ft. by 12 ft. by 5 ft. 6 in. deep, with Lifting Gear, &c., Complete. Excellent Condition. Low Price for early sale.
Offers to No. 7690, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

FOR SALE, Cheap, 50 to 60 Octagon and Fluted CAST IRON LAMP COLUMNS with Frogs and Ladder Arms, painted Aluminium.
What offers loaded up on Rail or Road?
Apply No. 7691, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

CONTRACTS OPEN.

CITY OF STOKE-ON TRENT.

(GAS DEPARTMENT.)

GAS CONSOLIDATION ACT, 1923.

CONTRACT No. 86.

THE Gas Committee invite Tenders for Six CAST-IRON PURIFIERS, HOUSE, MACHINERY, &c., at Etruria Gas Works.

Persons desirous of tendering are requested to make written application to the Chief Gas Engineer, Gas Works, Etruria, Stoke-on-Trent, not later than Monday, the 18th of October, and to enclose a deposit of £2 Treasury Notes, which will be returned on receipt of a *bona-fide* Tender and the return of all Plans and Documents, and also provided Tenders are received by the date mentioned.

Sealed Tenders to be forwarded to the undersigned not later than 12 noon on Monday, the 1st of November, 1926 and endorsed "Tender for Purifiers, &c., Gas Department."

E. B. SHARPLEY,
Town Clerk.

Town Hall,
Stoke-on-Trent,
Sept. 25, 1926.

STOCK ISSUES.

By Order of the Directors.

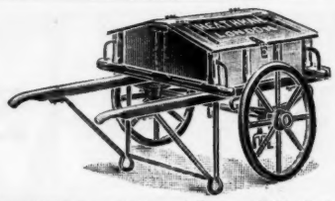
NEW ISSUE OF CAPITAL.

ROCHESTER, CHATHAM, AND GILLINGHAM GAS COMPANY.

Messrs. A. & W. RICHARDS
are Instructed to OFFER FOR SALE BY TENDER
£30,000
CONSOLIDATED ORDINARY STOCK,
ranking for a Standard Dividend of 5 p.ct. equally with existing similar Stock, now receiving under the Sliding Scale £6 10s. p.ct. per Annum.

Minimum Price of Issue, £92 10s. per £100,
Yielding £7 0s. 6d. per cent.

Prospectus and Form of Tender (which latter must be sent in by 11 o'clock on Thursday, Oct. 7) may be obtained of A. & W. RICHARDS, 37, WALBROOK, E.C. 4.



TRUCKS OF ALL KINDS.
HEATHMAN,
Parsons Green, Fulham,
London, S.W. 6.

TROTTER, HAINES, & CORBETT LIMITED
BRETTEL'S ESTATE,
FIRE-CLAY & BRICK WORKS,
STOURBRIDGE.

Manufacturers of GAS RETORTS, GLASSHOUSE FURNACE & BLAST FURNACE BRICKS, LUMPS, TILES, and every Description of FIRE BRICKS.
Special Lumps, Tiles, and Bricks for Regenerative and Furnace Work.
SHIPMENTS PROMPTLY AND CAREFULLY EXECUTED.

LONDON OFFICE: E. C. BROWN & CO., LEADENHALL CHAMBERS, 4, ST. MARY AXE, E.C.

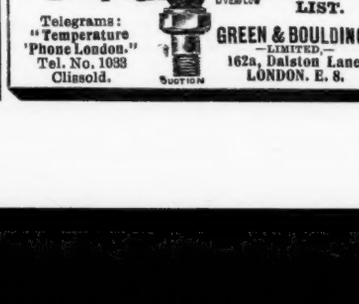
FOR 35 YEARS

BRISTOL'S REGISTERED TRADE MARK

NO RECORDING PRESSURE GAUGES AND THERMOMETERS Have Equalled
BRISTOL'S FOR ACCURACY AND LONG SERVICE.
More than 60,000 BRISTOL'S THERMOMETERS alone are used in every kind of Manufacturing.
10 Years' Guarantee.
Buy BRISTOL'S and Buy the Best
J. W. & C. J. PHILLIPS, LTD.,
23, College Hill, Cannon St., London, E.C. 4.

SPENCER'S
PATENT GRIDS
DOUBLE-BARRED
(for bottom tiers).
OPEN-SPACED "CLIMAX"
(for upper tiers).
INCLINED HEAVY-TYPE HURDLE
(for deep Filling).
FLAT-TYPE PATTERN
(made with patent bolts).
Prices and Sample sent on request.
W. SPENCER & SONS,
ELLAND, Yorks.
SOLE MAKERS AND PATENTEES.

'BUFFALO' INJECTOR



Operated Entirely by One Handle.
Class A lifts 24 ft.
Class B lifts 12 ft.
SEND FOR LIST.
Telegrams: "Temperature 'Phone London." Tel. No. 1033 Clissold.
GREEN & BOULDING, —LIMITED,— 162a, Dalston Lane, LONDON. E. 8.

GAS ENGINEERS!!!
Please write us for Prices, &c., of
GLICO LUBRICATING OILS.
Gas Engine Oils, Machine Oils, Turbine Oils, Exhauster Oils, Steam Cylinder Oils, and Conveyor Oils
OUR SPECIALITY.
For Prices, &c., apply to
GLICO PETROLEUM, LTD.,
ALEXANDRA HOUSE, QUEEN SQUARE,
LONDON, W.C.1.
Telephones: Museum 7400, 7401, 7402, 7403, 7404.
Telegraphic Address: "Carburine, Holb., London."

KOPPERS' CHAMBER OVENS.
KOPPERS VERTICAL OVENS.
KOPPERS' REVERSIBLE REGENERATIVE RETORT SETTINGS.
See large Advert. appearing in alternate issues of the "Journal."
For full particulars of the above systems apply to
KOPPERS' COKE OVEN CO., LTD.,
301, Glossop Road,
SHEFFIELD.
Telegraphic Address: KOPBOVEN, SHEFFIELD. *Telephones:* 1881, 1882 *and* 1883.

CAST IRON PIPES
FOR
GAS, WATER, & STEAM
1¼in. to 12in. BORE.
THOS. ALLAN & SONS, LTD.,
Bonlea Foundry,
THORNABY-ON-TEES.
Telegrams: "BONLEA, THORNABY-ON-TEES."
Telephone Nos: STOCKTON 821 and 822.

COCHRANE & CO.
(WOODSIDE), LTD.,
DUDLEY.
Manufacturers of
CAST IRON PIPES
FOR ALL PURPOSES.
Telegrams: "COCHRANE, WOODSIDE, DUDLEY." Telephone: DUDLEY 2426.

Cases for Binding Quarterly Volumes of the "Journal."
Price 3s. 6d. each, post free.
WALTER KING, LIMITED, "GAS JOURNAL" OFFICES, 11, BOLT COURT, FLEET STREET, E.C. 4.

INDEX TO "JOURNAL" ADVERTISERS.

	PAGE
Ackroyd & Best, Ltd.	725
Alder & Mackay, Ltd.	697
Aldridge & Ranken, Ltd.	742, 743
Allan, Thomas, & Sons, Ltd.	906
Anglo-American Oil Company, Ltd.	912
Arden Hill & Co.	703
Ashmore, Benson, Pease, & Co., Ltd.	Wrapper I, 727
Automatic Light Controlling Co., Ltd.	726
Babcock & Wilcox, Ltd.	737
Bagnall, John, & Sons, Ltd.	708
Bagshawe & Co., Ltd.	—
Baldwins, Ltd.	704
Bale & Church, Ltd.	731, 904
Barclay, A., Sons, & Co., Ltd.	701
Barrowfield Ironworks, Ltd.	690
Bates, J., & Sons	—
Berk, F. W., & Co., Ltd.	Wrapper I.
Blakeley (Firth), Sons, & Co., Ltd.	905, 906
Bourne, C.	713
Braddock, J. & J.	Centre XXIV, 881, 904
Braithwaite & Co., Ltd	—
Bray, George, & Co., Ltd.	724
British Aluminium Co., Ltd.	749
British Creosote Company, Ltd.	—
British Furnaces, Ltd.	736
British Gas Purifying Materials Co.	904
British Mannesmann Tube Co., Ltd.	911
British Thomson-Houston Co., Ltd.	—
Broadbent, Thos., & Son, Ltd.	705
Bromford Tube Co., Ltd.	687
Brown, John, & Co., Ltd.	912
Bruster & Richardson	—
Bugden, T., & Co.	—
Burt, Boulton, & Haywood, Ltd.	—
Cannon Iron Foundries, Ltd.	—
Carless, Capel, & Leonard	—
Carron Company	—
Cellactite Works, Ltd.	—
Chance Bros. & Co., Ltd.	Centre XIX.
Chapman (Spencer) & Messel, Ltd.	904
Chemical Engineering and Wilton's Patent Furnace Company, Ltd.	707
Clapham Bros., Ltd.	—
Clark's Lead & Colour Works Co.	911
Clark's Syphon Stove Co., Ltd.	—
Clayton, Son, & Co., Ltd.	919
Cloake, A. G.	—
Cochran & Co. (Annan), Ltd.	746
Cochrane & Co. (Woodside), Ltd.	906
Cockey, Ed., & Sons, Ltd.	734
Cort, Robert, & Son, Ltd.	710, 711
Cowan, W. & B.	Wrapper III.
Cozy Stove Co., Ltd.	Centre XIII.
Crossley Bros. (Bispham)	736
Crossley Brothers, Ltd. (Openshaw)	—
Cutler, Samuel, & Sons, Ltd.	Centre XVIII.
Danks, H. & T. (Netherton), Ltd.	715
Davis Gas Stove Co., Ltd.	701
Davison & Partner, Ltd.	—
Dempster, R. & J., Ltd.	694, 695
Dempster, R., & Sons, Ltd.	Centre II., III., 906
Denison, Saml., & Son, Ltd.	—
Donkin Co., Ltd. (The Bryan)	Wrapper II., 692
Dougall's Gas Meters, Ltd.	784
Drakes, Limited	Centre X, XI.
Drew-Bear, Perks, & Co., Ltd.	—
Dunn, Alexr., and Son	—
Duxbury, Thomas, & Co.	744, 904
Economical Gas Apparatus Construction Company, Ltd.	Centre XXIV.
Edie & Co, Ltd.	Centre XIII.
Electric Construction Co., Ltd.	918
Evans, Joseph, & Son (Wolverhampton), Ltd.	Centre XXIV.
Ewart & Son, Ltd.	741
Expanded Metal Company, Ltd.	—
F.C. Construction Co., Ltd.	842
Falk, Stadelmann, & Co., Ltd.	717
Fell, Anderson, & Co., Ltd.	735
Flack, D. L., & Son, Ltd.	723
Fletcher, Russell, & Co., Ltd.	693
Foster, E., & Co.	Centre XIII
Foster & Pullen, Ltd.	726
Fraser & Chalmers Engineering Works	—
Gas Purification and Chemical Co.	Wrapper I., 696, 904
Gas Meter Co., Ltd.	Wrapper IV., 738
General Gas Appliances, Ltd.	—
Gibbons Bros., Ltd	917
Gibbons (Dudley), Ltd.	916
Glenbolg Union Fireclay Co., Ltd.	908
Glico Petroleum, Ltd.	906
Glover, George, & Co., Ltd.	720
Glover, Thos., & Co., Ltd.	709, 750
Goodall, Clayton, & Co., Ltd.	912
Grant, David, & Co.	918
Grantham Boiler and Crank Co., Ltd.	—
Grayson, Lowood, J., & Co., Ltd.	703
Green and Boulding, Ltd.	906
Grice, Wm., & Sons, Ltd.	Centre XII.
Griffin, John J., & Son, Ltd.	743
Griffiths Bros. & Co. (London), Ltd.	Wrapper I.
Hall, John, & Co., Stourbridge, Ltd.	687
Hammond, G A. E.	908
Hardman and Holden, Ltd.	724
Harris and Pearson	902
Hawthorn Leslie & Co., Ltd.	—
Head, Wrightson, & Co.	Wrapper I, 730
Heathman, J. H.	906
Hislop, R. & G.	902
Holmes, W. C., & Co., Ltd.	689
Hooper & Weyman	—
Horseley Bridge and Engineering Company, Ltd.	Wrapper II.
Horstmann Gear Company, Ltd.	719
Hulse, F., & Co., Ltd.	731
Humphreys and Glasgow, Ltd.	748
Hunt & Mitton, Ltd.	—
Hurry Water Heater Co.	734
Hutchinson Bros., Ltd.	721
Incandescent Heat Co, Ltd.	729
Industrial Constructions, Ltd.	729
Ingram & Kemp	908
Integra Company, Ltd.	Centre XII.
Jeavons, E. E., & Co., Ltd.	—
Jenkins, W. J., & Co., Ltd.	913
Keith, James, and Blackman Company, Ltd.	920
King's Patent Agency	904
Kirkham, Hulett, and Chandler, Ltd.	Centre XXV.
"Kleenoff" Co.	731, 904
Koppers Coke Oven Co., Ltd.	906
Laidlaw, R., & Son (Edin.), Ltd.	914
Le Bas Tube Co., Ltd.	713
Lead Wool Company, Ltd.	696
Leeds and Bradford Boiler Co., Ltd.	703
Lighting Trades, Ltd.	747
London Electric Firm	734
Lord, J. E. C. (Manchester), Ltd.	904
Macpherson, Donald, & Co., Ltd.	—
Main, R. & A., Ltd.	Centre XIV., XV.
McKelvie, James, & Co.	Wrapper I.
Meltham Silica Fire Brick Co., Ltd	712
Menno Compressed Air Grease Cup Co. Ltd.	693
Metallon	—
Metropolitan Gas Meters, Ltd.	—
Mewburn, Ellis, & Co.	904
Midland Flexible Metallic Tubing Co., Ltd.	914
Midland Railway Carriage and Wagon Co., Ltd.	Wrapper IV.
Milne, J., & Son, Ltd.	731
Mitchell, H.	—
Mobberley & Perry, Ltd.	722
Moore, Walter, & Sons	Wrapper I.
New Conveyor Co., Ltd.	911
Newton, Chambers, & Co., Ltd.	Centre XXI.
Orme, George, & Co.	714
Oughtibridge Silica Firebrick Co.	707
Page, Chas., & Co., Ltd.	—
Parkinson Stove Company, Ltd.	Centre V.
Parkinson, W., & Co.	702, 740, 750
Pearson, E. J. & J., Ltd.	733
Peckett & Sons, Ltd.	726
Peebles & Co., Ltd.	736
Penney and Porter, Ltd	904
Phillips, J. W. & C. J., Ltd.	906
Piggott, Thos., & Co., Ltd.	688
Pneumatic Conveyance & Extraction, Ltd.	—
Pocock, Herbert	—
Potterton, Thos.	Centre XVI.
Premier Gas Engine Co., Ltd.	—
Pulsometer Engineering Company	Wrapper IV.
Purimachos Ltd.	718
Radiation, Ltd.	693, 701, 703, 713, 735, 745, Centre VI., VII.
Rational Carbonization Syndicate, Ltd.	Centre VIII.
Reavell & Co., Ltd.	724
Richmond Gas Stove & Meter Co., Ltd.	735
Ride and Bell, Ltd.	723
Riley, John, & Sons, Ltd.	—
Ritchie, J. & R., Ltd.	908
Ross, Chas., Ltd.	904
Rotary Meter Company, Ltd.	718
Sawer & Purves	Centre IV.
Scottish Tube Co., Ltd.	720
Sheepbridge Coal & Iron Co., Ltd.	Wrapper IV.
Shields & Ramsay	—
Siebe, Gorman, & Co., Ltd.	918
Simon-Carves, Ltd.	—
Simplex Concrete Piles, Ltd.	708
Smith, J. & W. B., Ltd.	—
Smith Meters, Ltd.	Centre XVII.
South Metropolitan Gas Company	914
Spencer-Bonecourt, Ltd.	Centre IV
Spencer Chapman & Messel, Ltd.	904
Spencer, Walter, & Sons (Elland)	906
Spencer, W., & Sons (Southall)	706
Sperryn & Co.	908
Stanton Ironworks Co., Ltd.	Centre XX.
Staveley Coal and Iron Co., Ltd.	739
Stein, J. G., & Co., Ltd.	Wrapper I., 700
Stephenson, Andrew	904
Stewarts and Lloyds, Ltd.	Wrapper I.
Stewart Browne & Co.	—
Stone, J., & Co., Ltd.	—
Stothert & Pitt, Ltd.	—
Stourbridge Refractories Co., Ltd.	—
Strachan & Henshaw, Ltd.	906
Stringer Bros.	—
Sugg, Wm., & Co., Ltd.	691
Sutherland Meter Company, Ltd.	716
Sutherland, A. G., Ltd.	909
Taylor, Joseph (Saturators), Ltd.	904, 910
Thames Bank (Blackfriars) Iron Co.	726
Thermal Syndicate, Ltd.	705
Thompson, John (Wolverhampton), Ltd.	—
Tilley High Pressure Gas Synd., Ltd.	—
Torbay Paint Company, Ltd.	Wrapper I.
Trier Bros., Ltd.	—
Trotter, Haines, and Corbett, Ltd.	906
Tully Sons & Co.	—
Turbine Furnace Co., Ltd.	Centre IX.
Turner, F.	733
United Water Softeners, Ltd.	—
Vale, Thos., & Sons, Ltd.	893
Vertical Gas Retort Synd., Ltd.	732
Walker, C. & W., Ltd.	Centre XIX.
Walker, Crosweller, & Co.	—
Waller, Geo., & Son, Ltd.	688, 728
Waugh, Walter, & Co., Ltd.	918
Wellington Tube Works, Ltd.	—
Welsbach Light Company, Ltd.	738
West's Gas Improvement Co., Ltd.	Centre XXII., XXIII.
Westwood & Wrights, Ltd.	915
Whessoe Foundry and Eng. Co., Ltd.	Centre XXVI.
Wholesale Fittings Co., Ltd.	699
Williamson, Cliff, Ltd.	Centre VIII.
Willey & Co., Ltd.	—
Wilson (George) Gas Meters, Ltd.	698, 904
Wilsons & Mathiesons, Ltd.	713
Winn, Chas., & Co., Ltd.	733
Wood, Hugh, & Co., Ltd.	706
Wood, Russell, & Co., Ltd.	737
Woodall-Duckham Co.	Centre I.
Wright, Alex., & Co., Ltd.	776
Wright, John, & Co.	745
Yorkshire Steam Wagon Co.	—

Appointments Vacant & Wanted	904
Company Notices	—
Contracts Open	906
Plant for Sale and Wanted	904, 906
Stock Issues	906

CAST IRON PIPES & SPECIALS

2" to 24" FOR ALL GASWORKS PURPOSES.

With Socket and Spigot, Flanged, Forster's Patent or Victaulic joints.

WE ARE STILL WORKING AT FULL PRESSURE &

WE HOLD A GOOD STOCK OF STANDARD SIZES.

J. & R. RITCHIE, LTD., *Acklam Foundry,*
MIDDLESBRO'.

Telephones : 52 & 53 MIDDLESBRO'. *Telegrams :* RITCHIE, MIDDLESBRO'.

OPAL SHADES
— FOR —
Howellite Gas Burners

4-inch - 40/- per gross
3 „ - 35/- „
CASE LOTS.

G. A. E. HAMMOND,
2, Lower James Street, Golden Square, W.1,
REGENT 6949.
or the
HOWELLITE CO., 85, Farringdon St., E.C.4.

HOWELLITE BURNERS AND ACCESSORIES.
All Sizes in Stock. Immediate Delivery.

---

2 names to Remember

SPERRYN
AND COMPANY
MOORSOM ST BIRMINGHAM
for Main Cocks & Gas Stove fittings of all descriptions

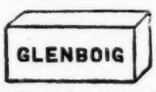
INGRAM & KEMP
ICKNIELD SQ. BIRMINGHAM
for Brackets and Pendants made to Gas Companies' requirements

---

THE GLENBOIG UNION FIRE-CLAY CO., LTD.

Manufacturers of the highest grade of Refractory Fire Bricks, specially suited for furnaces subjected to the highest heats and sudden changes of temperature.

All Glenboig Goods are stamped with either "Glenboig" or "Star Works, Glenboig" Brands as under—

REGISTERED TRADE  MARKS.

The Two Glenboig Brands are identical in quality and are used indiscriminately in the execution of orders.

GAS RETORTS HORIZONTAL, INCLINED, & VERTICAL RETORTS to New Standard Specification.
Special Bricks and Blocks for all modern Gas Settings.

Telegraphic Address:
"GLENBOIG, GLASGOW."

Glasgow Telephones
No. 2120 Douglas, No. 3009 Douglas.

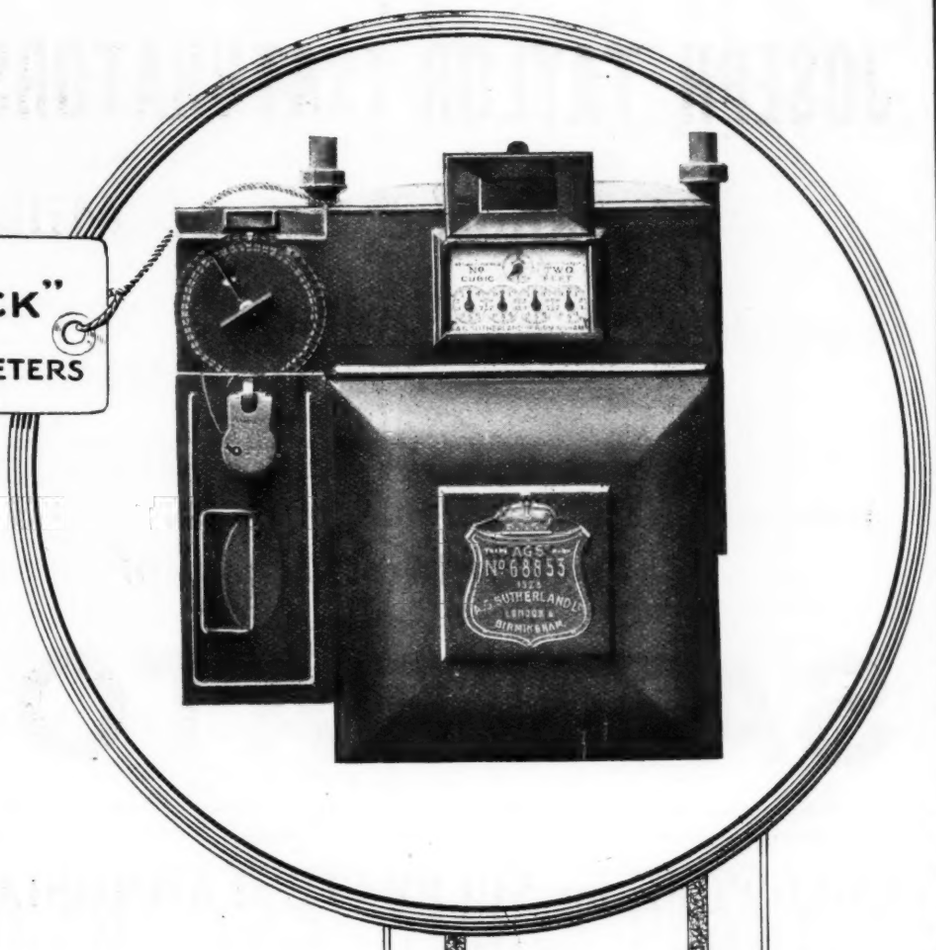
Coatbridge Telephone
No. 25

60 PRIZE MEDALS
At International and Home Exhibitions,
including
Grand Prize at Brussels, 1910.
In every case the Highest Award given for Fire Clay Goods.

Contractors to His Majesty's Home and Indian Governments, and the principal National Arsenals of Europe.
On the Admiralty and War Office Lists.

Works: GLENBOIG, GARTCOSH, and CUMBERNAULD.
Head Offices: 48, WEST REGENT STREET, GLASGOW.

THE
"WARWICK"
DRY GAS METERS



THE SECRET OF THE SUCCESS OF THE "WARWICK" METER LIES IN THE EXCELLENCE OF ITS PRODUCTION, DURABILITY, ACCURACY, AND ECONOMY OF MAINTENANCE.

Send Us Your Next Order.

A. G. SUTHERLAND LTD.
Warwick Road, Greet,
BIRMINGHAM

London Branch:
WARWICK WORKS, CHATHAM RD., BATTERSEA, S.W.11

When ordering specify "Warwick"

JOSEPH TAYLOR (SATURATORS) LTD.

Blackhorse Street Mills,

Bolton.

Manufacturers of

SATURATORS

AND

LEADWORK for SULPHATE of AMMONIA PLANTS

OVER 765

SATURATORS SUPPLIED.

SPECIALITY:

Saturators for making Neutral Sulphate.

Prompt Attention given to Repairs.

Telegrams: SATURATORS, BOLTON. Telephone: BOLTON 848.

5 in. Weldless Steel Main Bent Cold on Site.

GAS MAINS

OF

WELDLESS STEEL
(up to 14 in. Bore)

AND

WELDED STEEL
(from 14 in. up to 72 in. Bore)

THE
BRITISH MANNESMANN TUBE CO., LTD.
Corporation Road, NEWPORT, MON.

CLARKS of READING

THE VERY old established firm

MAKERS OF

LEAD & COMPO PIPES

SOLE PROPRIETORS OF

GASCOLITE grease remover
(registered)

Large stocks of all Sundries required by Gas Companies

Established 94 Years

MODERN GAS WORKS PLANT

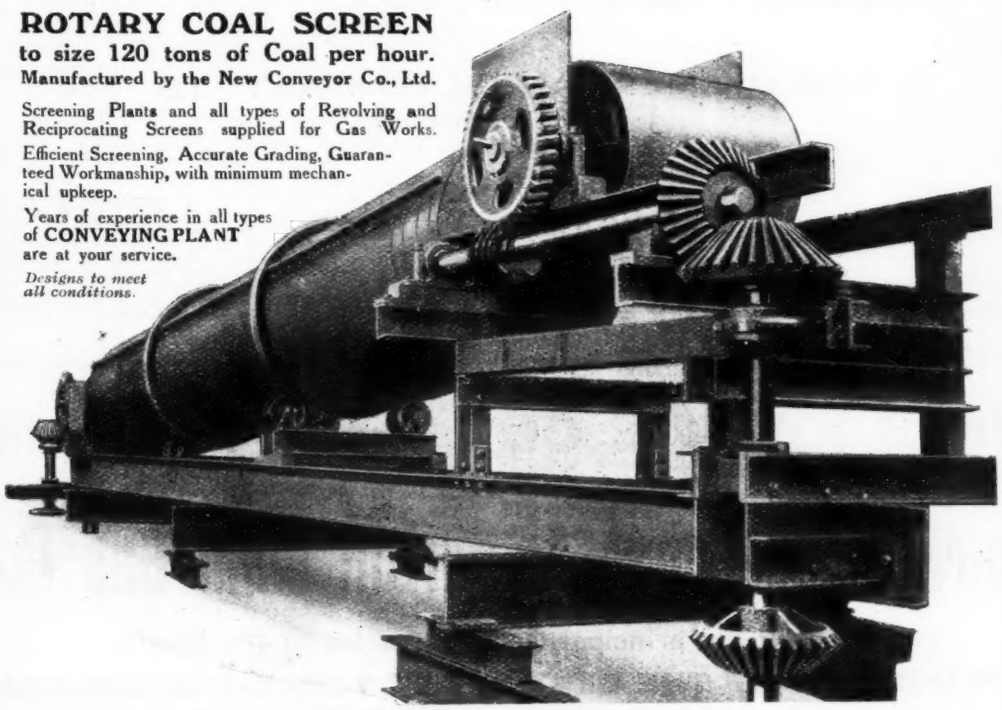
ROTARY COAL SCREEN
to size 120 tons of Coal per hour.
Manufactured by the New Conveyor Co., Ltd.

Screening Plants and all types of Revolving and Reciprocating Screens supplied for Gas Works.

Efficient Screening, Accurate Grading, Guaranteed Workmanship, with minimum mechanical upkeep.

Years of experience in all types of **CONVEYING PLANT** are at your service.

Designs to meet all conditions.

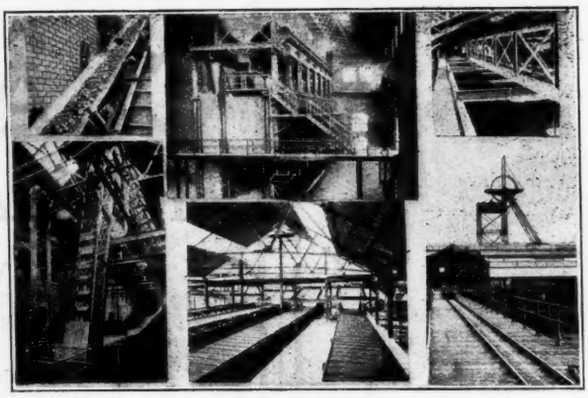


THE NEW CONVEYOR CO., LTD.,
SMETHWICK, BIRMINGHAM.

Telegrams: "Aptitude, Birmingham.

Telephone: 50 Smethwick.

GOODALL, CLAYTON & CO., LTD., LEEDS.



CONVEYORS, ELEVATORS, COAL BREAKERS, BUNKERS, ROOFS, HOISTS, Etc.

RETORT SETTINGS, PRODUCERS, FURNACES, REPAIRS.

COAL & COKE SCREENING & SIZING PLANTS.

GAS OIL

ANGLO-AMERICAN OIL COMPANY LTD.
36 Queen Anne's Gate
London
S.W.1
Branches & Depots Everywhere

ANGLOCO

JOHN BROWN & CO., LTD., Colliery Offices: **ROUNDWOOD, Nr. ROTHERHAM.**

OWNERS OF THE FAMOUS

Aldwarke, Rotherham, & Dalton Main Gas Coals

As used by the principal Gas Companies of the World.

ALSO PRODUCERS OF THE BEST SOUTH YORKSHIRE ASSOCIATED HARDS (BARNSLEY BED).

TELEGRAPHIC ADDRESS: "ROUNDWOOD, ROTHERHAM." TELEPHONE: ROTHERHAM 226.

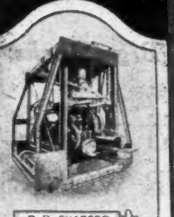
W. J. JENKINS & Co. LTD.

TELEPHONE
Nos 131 & 132 RETFORD
PRIVATE BRANCH EXCHANGE
DAY AND NIGHT

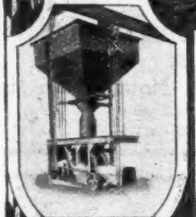
TELEGRAPHIC ADDRESS
"JENKINS RETFORD"
CODES USED
WESTERN UNION
A.B.C. 5TH EDITION

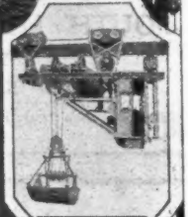
CONVEYING, CONSTRUCTIONAL & GENERAL ENGINEERS

MAKERS OF D. B. CHARGING AND DISCHARGING MACHINES
ALL CLASSES OF HANDLING PLANTS


D.B. CHARGER & DISCHARGER

TIPPLERS


D.B. CHARGER FOR STOP ENDS


TELPHERS

RETORT SETTINGS

NEW & RENEWALS

Brooke's Patent Regenerator

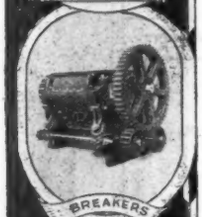
▫ ▫ ▫ ▫

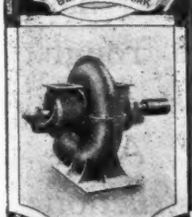
SEND FOR OUR NEW

ILLUSTRATED CATALOGUE
WHICH GIVES FURTHER
EXAMPLES OF OUR
MANUFACTURES

SENT FREE ON APPLICATION

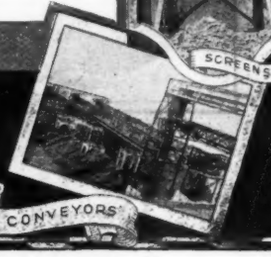
BENCH IRONWORK


BREAKERS


FANS

SCREENS

CONSTRUCTIONAL


CONVEYORS

BEEHIVE WORKS
RETFORD

LONDON OFFICE:
17, VICTORIA STREET, S.W.1.
TEL. No VICTORIA 5981

CHEMICAL PRODUCTS

Benzole, Toluole, Solvent Naphtha, Creosote Oils, Grease Oils, Carbolic Acid, Dark Cresylic Acid, Naphthalene, Pyridine, Anthracene, Refined Tar, Pitch.

Dry Neutral Sulphate of Ammonia, Sulphite of Ammonia, Muriate of Ammonia, Ammonium Chloride, Ammonium Polysulphide, Concentrated Ammonia Liquor, Liquor Ammonia.

Oxide of Iron for the purification of Gas, Sodium Sulphide, Ferric Sulphate, Copperas, Glauber's Salt, Sodium Hyposulphite, Nitre Cake, Salt Cake.

Sulphuric Acid of all strengths.

Intermediates for Dyes.

Manufacturers:

SOUTH METROPOLITAN GAS CO.,

Products Department,

709, OLD KENT ROAD, LONDON, S.E. 15.

Telephone: New Cross 2000. *Tel. Address: "Metrogas, Peak, London."*

"MIDFLEX" TUBING *for* GAS

(BRITISH MANUFACTURE)

In cut lengths, galvanised or enamelled finish, with or without Rubber or Metal Connections —and in long lengths.

□ □ □

$\frac{3}{16}$" to $2\frac{1}{2}$" ins. dia.——Flexible and Strong.

□ □ □

Prompt Despatch from Big Stocks.

□ □ □

ALL TUBING TESTED BEFORE LEAVING OUR WORKS

□ □ □

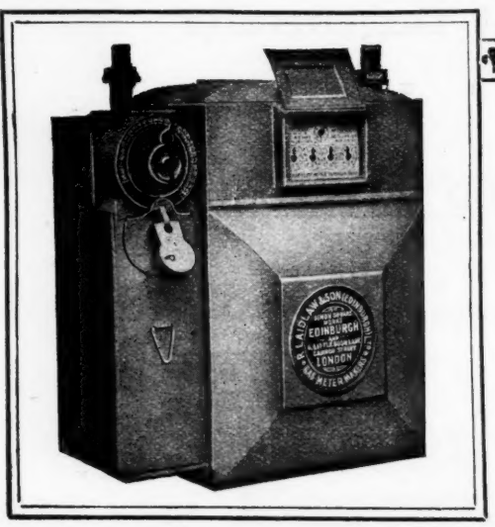
Midland Flexible Metallic Tubing Co., Ltd.

VULCAN WORKS,

Bridge Street, LONG EATON, Nottingham.

Telephone No. - - - - 50 Long Eaton.

Tel. Address - - "Flexible," Long Eaton.



PREPAYMENT METERS

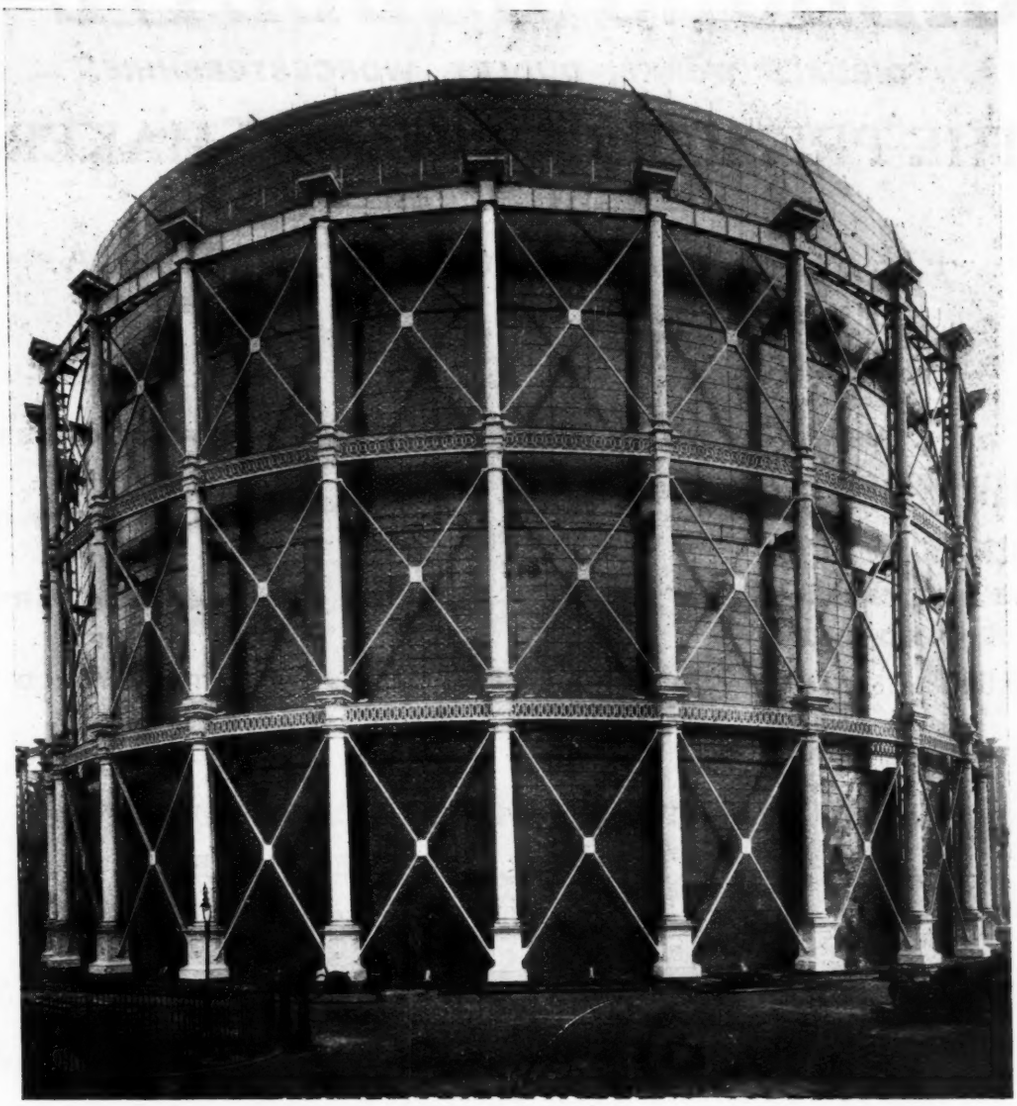
The prepayment meter has frequently to stand rough handling. There is no stronger meter on the market. Accurate, reliable construction

R. LAIDLAW & SON (Edin.) Ltd.

SIMON SQUARE WORKS, EDINBURGH

6, LITTLE BUSH LANE, LONDON, E.C.4

Repairs—Parts Supplied



EXISTING TWO-LIFT COLUMN-GUIDED GASHOLDER

EXTENDED TO

FOUR-LIFT GASHOLDER WITH SPIRAL-GUIDED INNER LIFT

(APPROX. 2,000,000 CUB. FT. TO 4,000,000 CUB. FT. CAPACITY)

FOR

THE GAS LIGHT AND COKE CO., BROMLEY-BY-BOW,

BY

WESTWOOD & WRIGHTS, LTD.

ENGINEERS,

TELEphone: Brierley Hill 45.
TELEgrams: Westwood Wrights.

BRIERLEY HILL, STAFFS.

GIBBONS (DUDLEY) LTD.

DIBDALE WORKS, DUDLEY, WORCESTERSHIRE,

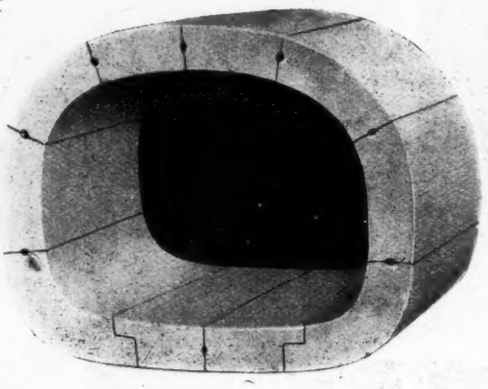
THE PREMIER GAS RETORT MAKERS

FIRECLAY. 65 % Silica.

SILICEOUS. 84 % Silica.

SILICA. 95 % Silica.

- - OF OUR - -
NEW QUALITIES
SILICEOUS & SILICA
WE HAVE ALREADY
- SUPPLIED OVER -
85,000 LINEAL FEET.

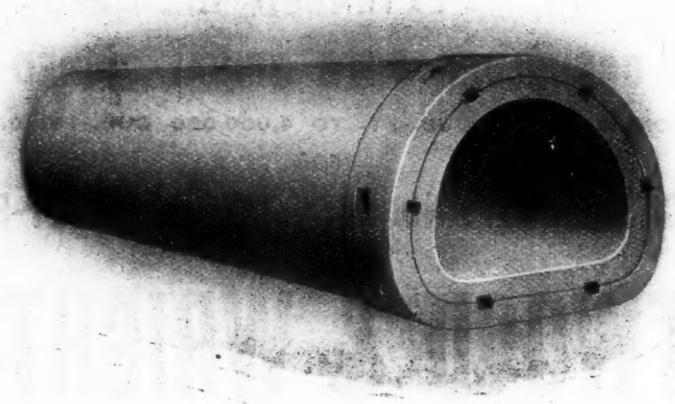


REPEAT ORDERS
- - FOR - -
ALL CLASSES OF
- RETORTS -
FROM ALL PARTS
- - OF - -
- THE WORLD. -

WE ARE IN A UNIQUE POSITION FOR SUPPLYING
——THE WANTS OF ALL GAS ENGINEERS.——

FIRST GRADE RETORTS, SILICA BRICKS, SILICEOUS BRICKS, No. 1 GRADE FIREBRICKS.

All Manufactured by the Latest Scientific Methods.



TELEPHONE: 2450 DUDLEY (2 lines).

TELEGRAMS: MACHINE, LOWER GORNAL.

Branch Offices:

LONDON, MANCHESTER, BRISTOL, AND MIDDLETON ST. GEORGE.

Proof Positive !

"Let facts speak for themselves."

In the Inner London area
we have set no less than

6,540 Retorts
(still in use)
in

GIBBONS Settings of "TENS"

Representing a daily potential output
approaching

125 Million cu. ft.

THE GAS LIGHT & COKE CO.		
BECKTON	261	
BROMLEY	104	
FULHAM	40	466
NINE ELMS	36	
SHOREDITCH	24	
COMMERCIAL GAS CO.		108
WANDSWORTH		60
BRENTFORD		12
NTH. MIDDLESEX		9

This is not the only Record which the

GIBBONS "TEN"

The Super-Setting

has established.

In overall efficiency, therm yield of straight gas per ton, yield of saleable coke per ton, it still stands

Pre-eminent

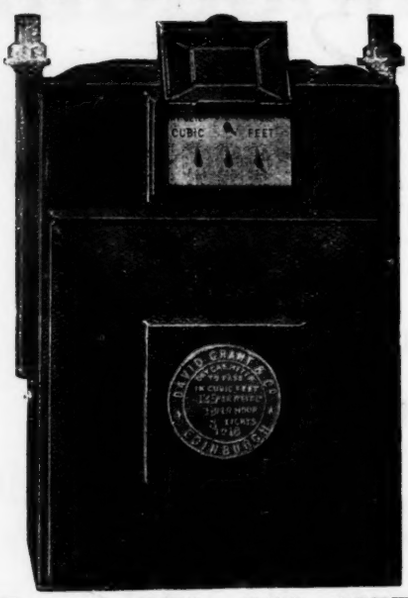
GIBBONS BROS. LTD.

151-154, PALACE CHAMBERS,
WESTMINSTER, S.W. 1

Head Office—
Dibdale Works,
Dudley, Worcs.

ESTABLISHED 1855.

DAVID GRANT & CO.



WET and DRY GAS METERS,

STANDARD DRY METERS,

STATION METERS, PRESSURE GAUGES, SYPHON PUMPS.

SLOT METERS Simple, Strong, Compact, Accurate.

EAST CROSSCAUSEWAY, EDINBURGH.

Telegrams: "DAGRAM EDINBURGH." Telephone: MUSEUM 574.

"ANTIPOYS"

Patent Short Distance Breathing Apparatus for men working about gas mains, &c. Adopted by all the principal Gas Companies.

ALSO MAKERS OF

SMOKE HELMETS of all patterns,

SELF-CONTAINED OXYGEN BREATHING APPARATUS,

OXYGEN RESUSCITATING APPARATUS,

RESPIRATORS, and

All other Safety and Protective Appliances.

SIEBE, GORMAN & CO., LTD.

187, WESTMINSTER BRIDGE RD., LONDON, S.E.1.

Telegrams: "SIEBE, Lamb, London." Telephone No. Hop 3401 (2 lines).

Walter Waugh & Co., Ltd.,

4, LLOYDS AVENUE,
LONDON, E.C. 3.

Telegraphic Address: "Swaltaugh, Fen., London." Telephone: 6660 Avenue (3 lines)

TAR, AMMONIA, AND CYANOGEN PRODUCTS.

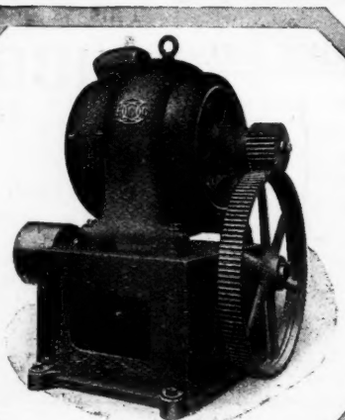
PITCH A SPECIALITY.

ELECTRICAL ECC MACHINERY

FOR

GAS WORKS POWER PLANT

GENERATING PLANT AND SWITCHGEAR



MOTORS AND CONTROL GEAR

Head Office

Ingersoll House, 9, KINGSWAY. LONDON. W.C. 2.

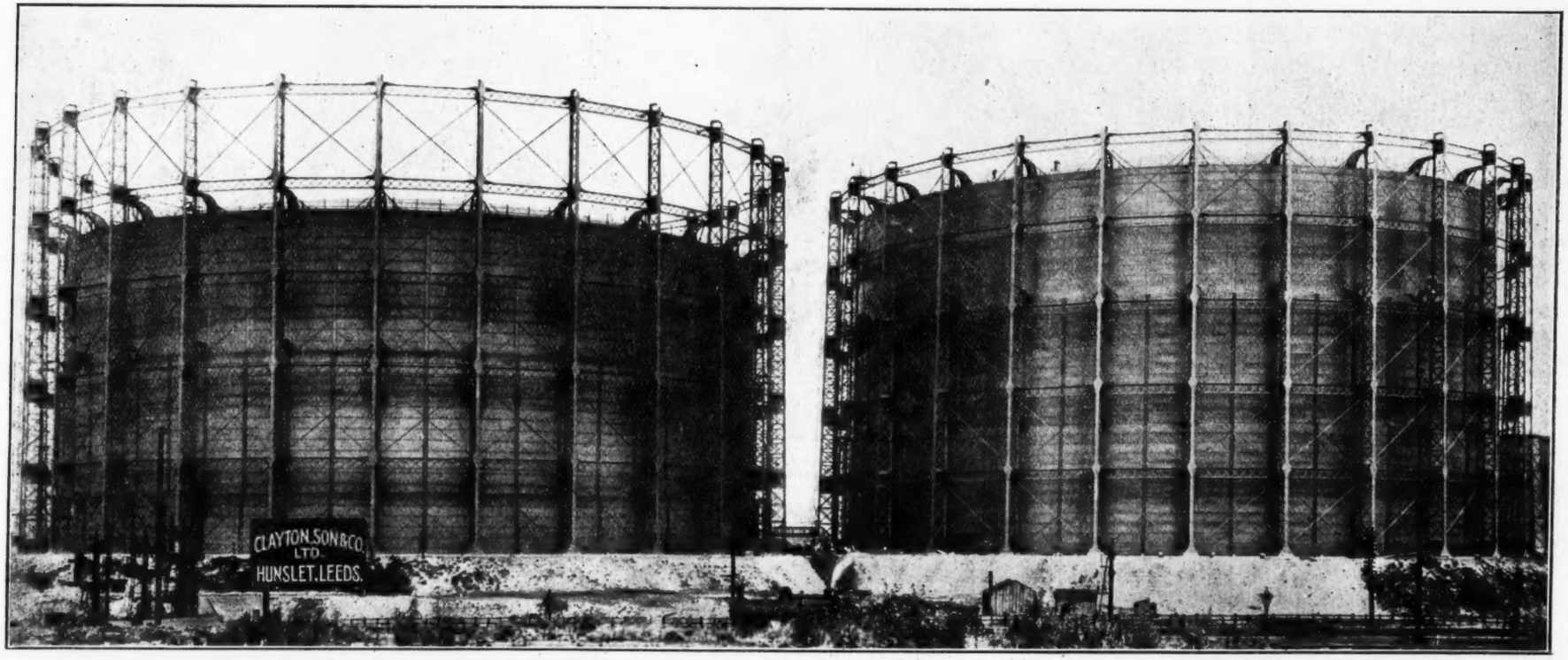
WORKS

WOLVERHAMPTON.

Telegrams: CONCORDANCE ESTRAND LONDON. ELECTRIC WOLVERHAMPTON. *Telephone Nos:* GERRARD 8833 & 4606. WOLVERHAMPTON 1455 & 1456.

THE ELECTRIC CONSTRUCTION Co LTD

CLAYTON, SON & CO., Ltd., HUNSLET, LEEDS



TWO THREE-LIFT TELESCOPIC GASHOLDERS, each prepared for Two Additional Lifts

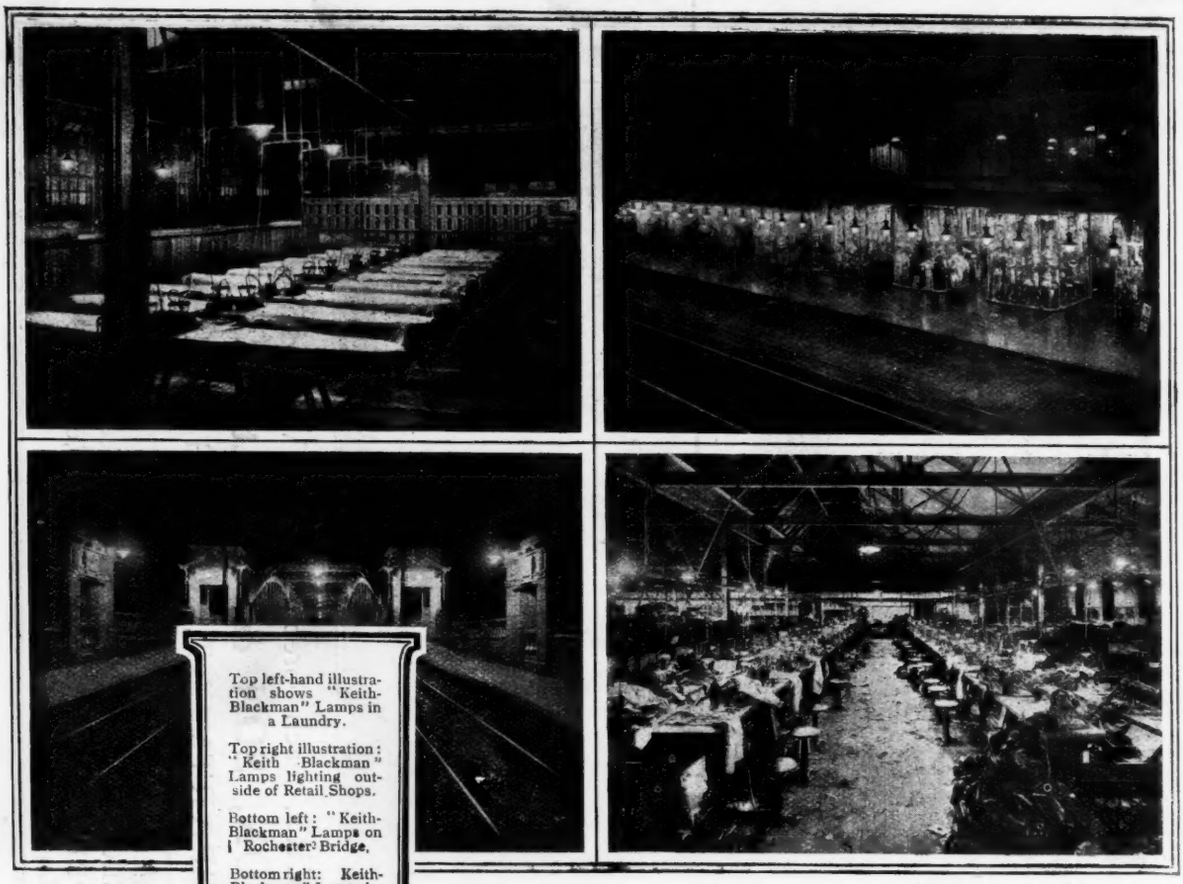
Made and erected by CLAYTON, SON & CO., Ltd.

for the CITY OF BIRMINGHAM GAS DEPARTMENT, Washwood Heath Works

DIMENSIONS:

INNER LIFT	-	241 feet dia. by 44 feet deep	SECOND LIFT	-	243 feet 8 in. dia. by 44 feet deep
THIRD LIFT	-	246 feet 4 in. dia. by 44 feet deep	PRESENT CAPACITY	-	6,000,000 cubic feet each

ENGINEER - - - - JOHN FOSTER, Esq.



Top left-hand illustration shows "Keith-Blackman" Lamps in a Laundry.

Top right illustration: "Keith Blackman" Lamps lighting outside of Retail Shops.

Bottom left: "Keith-Blackman" Lamps on Rochester Bridge.

Bottom right: Keith-Blackman" Lamps in a Clothing Factory.

Our contribution to the Lighting Load!

OUR contribution to the *lighting* load of Gas Undertakings comprises a wide range of high pressure gas lamps and fittings suitable for the lighting of factories and workshops, streets and parades, shops, railway stations and sidings, etc. In their various sizes, from the smallest 60 c.p. lamp for indoor use to the large 4500 c.p. lamp for outdoor lighting, these lamps give a perfect light at the maximum efficiency.

Users of artificial light want lamps that will give them a brilliant illumination for a low cost. Candle power for candle power, no other lamps can give such a high efficiency as our lamps, and undoubtedly more lighting business can be secured for gas—even against the keenest competition—if these lamps are specified.

JAMES KEITH & BLACKMAN Co LTD

Head Office: 27, Farringdon Ave., London, E.C. 4.

MANCHESTER: 4, Cannon Street. BIRMINGHAM: 21, Waterloo Street. LEEDS: 36, Royal Exchange. GLASGOW: 90, Mitchell Street.
And at Newcastle, Cardiff, Sheffield, Bristol, and Belfast.

Keith-Blackman
HIGH PRESSURE GAS LAMPS

Printed (at the Chancery Lane Printing Works, Ltd.), for WALTER KING, LIMITED, 11, BOLT COURT, FLEET STREET LONDON, E.C. 4.—Wednesday, September 29, 1926